# Pre deployment Setup Report for Roadworks, Roads and Lane Closure Validation

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| Lead beneficiary: | BE_Be-Mobile |
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# 2 Introduction

## 2.1 Purpose of the Deliverable

This merged Deliverable D3.2 / D3.3 consolidates both deliverables into a single document, owing to the strong methodological overlap in validation and data quality improvement approaches for road works (T3.2), road closures, (T3.3) and lane closures (T3.3). Given the similarities in data lifecycle management, validation logic, and quality improvement mechanisms across these datasets, a unified framework ensures consistency, efficiency, and harmonized implementation across all PDV's.

The document opens with a state-of-the-art overview of the current end-to-end (E2E) processes implemented by each PDV. These descriptions cover the full data lifecycle — from planning and data collection to validation, KPI measurement, and data quality improvement — including the tools, systems, and operational workflows applied at each stage. Where relevant, the integration of Floating Car Data (FCD) and Road User Feedback (RUF) into validation, maintenance, and quality improvement processes is described. Where such integration is not yet operational, the document outlines the planned approach for incorporating FCD and RUF into PDV systems and workflows, explaining how these enhancements are expected to strengthen validation mechanisms, improve quality improvement processes, and ultimately increase the quality and reliability of navigationservices. Additional detailed descriptions and supporting information per PDV are included in the Annex.

Beyond documenting the current situation, this deliverable serves as a practical methodological framework to structure validation activities, data quality improvement strategies, and E2E process optimization. It functions as a gap-closing instrument by identifying weaknesses in existing PDV processes and providing concrete, actionable solutions to address them.

Within this framework, the TISA RTTI 5-Star Rating is taken as a good example of a common validation methodology. It is a specification with clearly defined KPIs per attribute and per dataset type. The document further gives handholds for PDV's to execute the 5-Star Rating in practice: which methods to apply, which ground truth sources to use, how to collect and prepare historical data, and how to ensure consistent KPI measurement. The 5-Star Rating is complemented by additional validation and quality improvement approaches to support continuous quality improvement.

The deliverable also captures and formalizes reusable best practices identified across different PDV's, supporting harmonized and scalable implementation. It is intended as a mandatory reference document for preparing and initiating pre-deployment validation activities. The document does not contain validation results; instead, it provides the methodological foundation that PDV's can apply.

Finally, this deliverable serves as a methodological input for the individual PDV Project Plans. Each PDV remains responsible for developing and managing its own PDV Plan during the course of the project (to be delivered as part of D3.5 and D3.6), in which they will describe in detail the concrete actions to be implemented to improve the end-to-end process, strengthen validation methods, and enhance the overall quality of the datasets. The template of the PDV Plan is offered in Annex.

# 3 PDV Information

## 3.1 General information

In table below an overview is provided of the PDV Sites, their involvement in Task 3.2 - Task 3.3 and information on the SPOC per PDV.

Regarding this list of PDV's, note that contacts from Greece national authorities were originally part of this Deliverable. However, they were unable to provide contributions to the content, so they were removed from the tables in the interest of clarity.

| Code | PDV Description | PDV NR | 3.2 | 3.3 | Organization | Spoc | Mail |
|---|---|---|---|---|---|---|---|
| BEL-Flanders | Flanders: national & regional roads | 2 | x | x | BE-AWV | Patrick Deknudt | patrick.deknudt@mow.vlaanderen.be |
| BEL-Antwerp | Antwerp (Urban node , all roads) | 1 | x | x | BE-Lantis | Joeren Vanhoutte | jeroen.vanhoutte@vervoerregioantwerpen.be |

| Code | PDV Description | PDV NR | 3.2 | 3.3 | Organization | Spoc | Mail |
|---|---|---|---|---|---|---|---|
| CYP | Nicosia District (Urban Node) | 3 | x | | CY- Public Works Department (PWD.MDW) | Rodolfo Da Silva | gomes-da-silva.rodolfo-leonel@ucy.ac.cy |
| FIN-Tunnel | National Tunnel Roads | 5 | | x | FI_FINTRAFFICROAD | Jani Laiho | jani.laiho@fintraffic.fi |
| FIN- Roads | Nationwide main roads | 6 | x | | FI_FINTRAFFICROAD | Jani Kariniemi | jani.kariniemi@fintraffic.fi |
| FRA-Med | Road Directorate Mediterranee (National Road 568) | 7 | x | x | FR_CEREMA | Jean Philippe Mechin | Jean-Philippe.Mechin@cerema.fr |
| FRA-Herault | Départment of Hérault | 8 | x | x | FR_CEREMA | Jean Philippe Mechin | Jean-Philippe.Mechin@cerema.fr |
| FRA-Nice | Metropole of Nice Cote D' Azur (75km of urban roads) | 9 | x | x | FR_CEREMA | Jean Philippe Mechin | Jean-Philippe.Mechin@cerema.fr |
| HR CR | Section of State Roads | 11 | | x | HR_CR (Croatian Roads_Hrvatske ceste d.o.o) | Irena Cacic | irena.cacic@hrvatske-ceste.hr |
| ITA | Port of Spezia | 12 | x | x | IT_SPE | Simone Pacciardi | simone.pacciardi@adspmarligureorientale.it |
| NLD-Ams | City Of Amsterdam | 15 | x | x | City Of Amsterdam | Leon Zegers | l.zegers@amsterdam.nl |
| NLD-Hel | City Of Helmond | 14 | x | | NL_HELMOND | Martin de Vries | martin.devries@helmond.nl |
| ESP | Spanish interurban roads | 4 | x | | ES_DGT | Montse Estaca | mestaca@dgt.es |
| SWE | City Of Gothenburg (National/ State roads around Gothenburg | 16 | x | x | SE_TRAFIKVERKET | Joakim Barkman | joakim.barkman@trafikverket.se |

| Code | PDV Description | PDV NR | 3.2 | 3.3 | Organization | Spoc | Mail |
|---|---|---|---|---|---|---|---|
| | and streets and roads in Gothenburg) | | | | | | |
| SVN | National Motorways (625 km) and secondary road network (1743 km) | 17 | x | x | SI_MIS | Jure Dolenc | jure.dolenc@appia.si |

*Table 1: Overview of PDV's & related Spocs*

The table below presents an overview of the stakeholders for each PDV.

| PDV Site | Public Authority (Legal) | Road Authority | NAP/ Platforms | Service Providers | Data Sources | Supporting organizations | Through which navigation services offered to End Users |
|---|---|---|---|---|---|---|---|
| BEL-Flanders | | AWV, Lantis | NGI | Be-Mobile, Movias | | | |
| BEL-Antwerp | | Latis, Stad Antwerpen | NGI | Be-Mobile, Movias | Be-Mobile (FCD) | | |
| CYP | Public Works Department (PWD) | Public Works Department (PWD) | CyNAP - traffic4cyprus.org.cy | No | FCD on roads under PWD authority<br><br>Waze is offering events | KIOS CoE – University of Cyprus | Waze is using own event, not using the Cyprus offered events.<br><br>No SP in Cyprus, no one willing to use the NAP data |
| FIN-Tunnel | | Fintraffic Road -Traffic manament center | Fintraffic Mika Ahvenainen | Here'?<br><br>Tripservice ? | TomTom, Waze (FCD) | | Here, Waze<br><br>Tripservice ? |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| FIN-<br><br>Roads | | Fintraffic Road -Traffic manament center | Fintraffic Mika Ahvenainen | Here'?<br><br>Tripservice ? | TomTom, Waze (FCD) | | Here, Waze<br><br>Tripservice ? |
| FRA-Med | Direction Interdépartemental des routes de Méditerranée | Frecnh Minstry - | https://www.bison-fute.gouv.fr/directive-sti,langen.html | | | | |
| FRA-Herault | Conseil départemantal de l'Hérault | Conseil départemantal de l'Hérault | https://inforoute.herault.fr/ | | | | |
| FRA-Nice | Métropole Nice Côte d'Azur | Métropole Nice Côte d'Azur | https://inforoute.herault.fr/<br><br>without traffic information | | | | |
| HR CR | Hrvatske ceste d.o.o | Hrvatske ceste d.o.o. | NAP (https://www.promet-info.hr) | Hrvatske ceste d.o.o. | Traffic Management Centres (MTCC) VIATEL (FCD) | | Service providers registered on the NAP |
| ITA-La Spezia | | Port System Authority of the Eastern Ligurian Sea | | | | | |
| NLD-Ams | City of Amsterdam | city of Amsterdam | NDW | Here, Be-Mobile | MELVIN | NDW | |
| NLD-Hel | City of Helmond | City of Helmond | NDW | n.a. | GEORGE | NDW | n.a.<br><br>(via NDW) |
| ESP | Jefatura Central de Tráfico | Dirección General de Tráfico (DGT) | https://nap.dgt.es/ | N/A | Road contractor through TRAZA and RENO apps into LINCE.<br><br>TMC and ATGC (police)<br><br>External integrations into LINCE of WAZE and DGT 3.0 (IoT device), | | Waze<br><br>HERE<br><br>TomTom<br><br>Google<br><br>Coyote |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SWE | Trafikverket (STA), City of Gothenburg | Trafikverket (STA), City of Gothenburg | trafficdata.se | N/A | Inrix (FCD on major roads) | | Waze, Google, HERE, TomTom, Apple |
| SVN | SI-MIS | DARS | nap.si | TIC DARS | NEZ | | Waze, partially other providers |

*Table 2: Stakeholders per PDV*

# 4 Inputs for Deliverable

## 4.1 Process to come to validation method

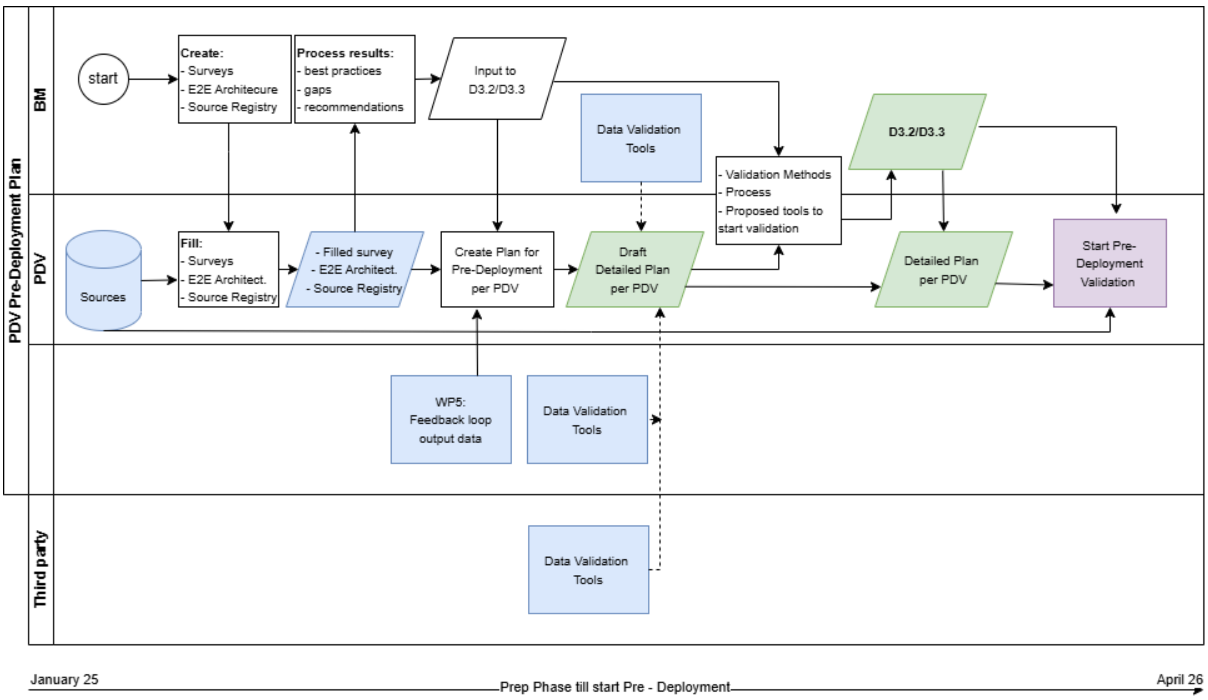



*Figure 1: Process to come to validation method*

Figure 1 shows how Be-Mobile (BM), as main responsible partner for the development of a validation method, proposes different steps in collaboration with the PDV's. It shows the steps leading to this deliverable of which the outcomes are described below. Afterwards, this deliverable will be used to further draft a detailed PDV plan template, which records for each PDV their chosen validation method and process, tools to be used/needed, and future improvements on these processes. At this point, the PDV's will be ready to start the pre-deployment validation phase. Furthermore, this diagram shows the interaction during this process with service providers (SP's) in the form of feedback (worked out in WP5), which is further described in Validation Objectives and Principles 8.2.

### 4.2 Surveys

At start of the project a general survey was sent to all involved partners of T3.2 & T3.3.

The survey was split in 2 parts:

- Part 1: General questions about your PDV site, current status, high-level data processes, initial quality and validation approaches, technical environment, and expectations for tasks T3.2 and T3.3.
- Part 2: Detailed questions focusing on the road works, road closure and lane closure data, definitions, attributes, data delivery, metadata, current validation workflows, feedback procedures, and identification of any missing tools or elements.

During the KOM of T32-T33, an extra survey was performed by means of a Mentimeter.

A third survey took place during the Utrecht Workshop.

All high level survey results are consolidated in Chapter 5. High level survey results PDV's

# 5 High level survey results PDV's

### 5.1 PDV – Roadworks - state of the art

| PDV Site | Source: Role contractor | RW Coverage/Completeness | Temporal data stored | Platform for publishing | Location Type | Data Format | Georeferencing Method | Update Frequency | Ground truth |
|---|---|---|---|---|---|---|---|---|---|
| BEL-Flanders | Report RW | Quite high on motorways | Start/end times | NAP (only meta data) | Point, polygon | Datex II v3 | Coordinates, no preference | Feed as a whole is updated every min., including changes on RW made in that interval | Detectors, TM center, inspection |
| BEL-Antwerp | Report RW | Currently the process is triggered by road-work and event permits | Start/end times | NAP (only | Point, polygon | Datex II V2 till V3, intern | Coordinates | Ad hoc as needed, via e- | Detectors, TM center, |

| PDV Site | Source: Role contractor | RW Coverage/Completeness | Temporal data stored | Platform for publishing | Location Type | Data Format | Georeferencing Method | Update Frequency | Ground truth |
|---|---|---|---|---|---|---|---|---|---|
| | | being issued and all data are manually verified with the roadwork planning team. Only RW with major impact are published to be able to ensure quality. | | meta data) | | al format | | mail, phone | inspection |
| CYP | Report RW | N/A because no ground truth currently available. Planned to be available for roads under PWD authority in Q2 2026. | Start/end times | NAP (metadata and interactive map) | Point (tbc) | Datex II v3 | Basic GNSS coordinates, Link based selected on map | As needed | Traffic Control Centre (FCD, CCTV, etc) |
| FIN-<br>Roads | Report RW | National road network | Start/end times | NAP | Linear and Point | Datex II v3 | OpenLR in future Alert-C and GML currently | As soon as possible | Traffic controls center |
| FRA-National Road Directorate Mediterranee | Report RW | National Road Network | Forecast Start/end times<br><br>Realtime Start/end times | NAP under Bison Futé website with subscription (free) | Linear (Alert-C, Marker post and a sort of TPEG Loc) | Datex II v2 | Marker post, marker post and AlertC | Forecast and real with update | Traffic Control Centre |
| FRA-Herault | Report RW<br>Departemental roads | | | | | Datex II v2 | Marker bost, marker post and AlertC | | |
| FRA-Nice | | | | | | Datex II v2 | Marker bost, marker post and AlertC | | |
| ITA – Port of La Spezia | Not report RW | Only when data is published as presidential order | | Not on NAP | | | | Ad hoc, via e-mail, phone | |
| NLD-Ams | Not report RW, can provide TMM | MELVIN, used for road works | Start/end times | NAP (all data) | Point, polyline, | Datex II V2 till V3 | Linear referencing, | Instant | TM center, private FCD, inspectio |

| PDV Site | Source: Role contractor | RW Coverage/Completeness | Temporal data stored | Platform for publishing | Location Type | Data Format | Georeferencing Method | Update Frequency | Ground truth |
|---|---|---|---|---|---|---|---|---|---|
| | | IDEA, real time information about actual traffic on planned road works.<br><br>IM backbone provides information about incidents on the roads. A dashboard (DAISI) is provided with this information. | | | links/nodes | | coordinates, OpenLR | | n, public data |
| NLD-Hel | Contractors,<br><br>Service providers, event organizations<br><br>Provide RW design | High | Start/end times | Backbone of NAP (NDW) | Point, polyline, links/nodes | See NAP | unknown | Instant | From design in AutoCAD |
| ESP | Report RW | According to law 100% of RWs should be reported, but the reality is that not all of them are informed by RA and contractors. | Start/end times | NAP (all data) | Points, links/nodes | Datex II v3.6 | Coordinates WG84 | Every minute | Cameras, contractors, ATGC |
| SWE- | Report RW | Source data quite often lack positional accuracy and timeliness even though the overall coverage and completeness for state roads is OK. | Start/end times, recurrence | Published on own portal linked to NAP | Point, polygon, links/nodes | Datex II v3 | Coordinates WGS84, OpenLR, GML | As soon as possible | Detectors, TM center, inspection |
| SVN | Report RW | National roads and highways | Start/end times | Published on own portal linked to NAP | Point, polygon, links/nodes | Datex II v3 | Coordinates WGS84, OpenLR, GML | Real time | TM center |

| PDV Site | Source: Role contractor | RW Coverage/Completeness | Temporal data stored | Platform for publishing | Location Type | Data Format | Georeferencing Method | Update Frequency | Ground truth |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

*Table 3: PDV - Road works – General information*

| PDV Site | How do you rate your RW Quality | E2E process effectiveness | RW Validation | Validation Method used today? | RW Quality Metrics Used | How do you receive feedback on Q? | How do you maintain RW info | Navigation Services using the data? | RW Key Gaps | RW Improvement needs |
|---|---|---|---|---|---|---|---|---|---|---|
| BEL-Flanders | Medium/partial | Relies largely on human input | Ad-Hoc | Camera/manually | | Ad hoc automation needed | GIs & Excel | Sometimes, unclear | No info on planned events | Adding SP data, linking WERF to permit granting |
| BEL-Antwerp | Medium/partial | Robust, but dependent on human knowledge | Ad-Hoc | Manually | | Ad hoc automation needed | GIs & Excel | TBD | Conversion from internal format to Datex | Tooling for common data streams, *Publish Datex-II, Collect feedback, Set-up process to evaluate and incorporate feedback in data.* |
| CYP | Low/limited | Paper-based currently. Planned to be available for roads under PWD authority in Q2 2026. | Ad-Hoc | Manual, Telephone check with contractors, Waze (events) | | Ad hoc automation needed | GIS (starting in Q2 2026) | No | Paper-based currently. | Conversion to digital workflow |
| FIN-Road | High/Mature | Digital | By RA | TMC operators checking | | Ad hoc automation needed | Separate portal | Sometimes | Make the data visible and enable feedback \| Satellite data combined with other data sources | Common algorithms |

| PDV Site | How do you rate your RW Quality | E2E process effectiveness | RW Validation | Validation Method used today? | RW Quality Metrics Used | How do you receive feedback on Q? | How do you maintain RW info | Navigation Services using the data? | RW Key Gaps | RW Main Improvement needs |
|---|---|---|---|---|---|---|---|---|---|---|
| FRA-Med | Medium/Partial | | Ad-Hoc | Manually | | | | Sometimes | | Good description of the workflow and standards to be used |
| FRA-Herault | Medium/Partial | | Ad-Hoc | Manually | | | | Sometimes | | Good description of the workflow and standards to be used |
| FRA-Nice | Medium/Partial | | Ad-Hoc | Manually | | | | Sometimes | | Good description of the workflow and standards to be used |
| ITA – Port of La Spezia | | Administratively driven rather than data-driven | Cert. satisfactory execution | | | Ad hoc automation needed | Presidential order to maintain | Taken up when data is published as presidential order | Conversion to a digital framework | |
| NLD-Ams | Medium/Partial | High quality, through VIctor application | Lite checks by RA | IDEA, Traffic management centre, field operators | | Ad hoc automation needed | MELVIN | Sometimes, unknown | Feedback loop | Contractor engagement / collaboration \| Method for finding ground truth |
| NLD-Helmond | High | Highly effective in general.<br><br>Some SP's may incidentally not use the NAP data, but there is no formal connection to them to the RA. Also no feedback on the actual use. | The RA validates the planned RW and enters this into the system | Based on the design of the RW in an AutoCAD drawing supplied by the contractor.<br><br>Standards set by CROW.<br><br>The IDEA system provides feedback on conflicts with other RW. | Aspects: Consistency, time plan, estimated effect on traffic flow/throughput, interaction with other RW measures | In principle no feedback, otherwise only<br><br>ad hoc. Automation needed | LTC Andes<br><br>(with export to NDW backbone/MELVIN).<br><br>Consider migrating to MELVIN | All connected to the NAP | Active feedback loop, especially on timeliness.<br><br>Under discussion with NAP. | Timeliness. |

| PDV Site | How do you rate your RW Quality | E2E process effectiveness | RW Validation | Validation Method used today? | RW Quality Metrics Used | How do you receive feedback on Q? | How do you maintain RW info | Navigation Services using the data? | RW Key Gaps | RW Main Improvement needs |
|---|---|---|---|---|---|---|---|---|---|---|
| ESP | The quality of the information included is HIGH but not all RWs are included. | Effective with all steps confirmed by staff, despite the reliance on human input for data collection. | Ad hoc | ATGC (Police), TMC (cameras) and WAZE input. | | | Using validation methods | Sometimes | Use IoT device | RA and contractors' engagement. |
| SWE | Medium/Partial | Good | Ad hoc | Sample measurements through site inspection | | Ad hoc automation needed | Inhouse SW | Yes, but false positives due to planned road works being shown | Resources to implement process to use many sources, validation | Contractor engagement / collaboration. Georeferencing and timeliness. |
| SVN | High | Effective, with all steps confirmed by staff | The RA validates the planned RW and enters this into the system | Manually | | | NEZ | The live feed is used by WAZE. The other service providers publish some of the information, but not promptly. | Validation | Automatization of the validation |

*Table 4: PDV - Road works - Validation Summary*

## 5.2 PDV – Roadclosure & Laneclosure – State of the art

| PDV Site | Source: Role contractor | RW Coverage | RW Data Completeness | Temporal data stored | Platform for publishing | Location Type | Data Format | Georeferencing Method | Update Frequency | Ground truth |
|---|---|---|---|---|---|---|---|---|---|---|
| BEL-Flanders | Do report RW | | | | | | | | | |
| BEL-Antwerp | RC and Events are part of RW process, see table 1. LC currently not implemented. | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| FIN- Tunnel Roads | Do report RW | National highways and tunnels | | | NAP | Point and Linear | Dadex2 3.5, hopefully Datex 4.0 in near future | Alert-c, will be OpenLR | Real time | TMC knows what they have done |
| FRA-Med | | | | | | | | | | |
| FRA-Herault | | | | | | | | | | |
| FRA-Nice | | | | | | | | | | |
| HR CR | Report RW and RC together | National State Road Network | Start/end times | NAP (data, metadata, and interactive map) | Point, linear (road segments) | Datex II v3 | Coordinates, linear referencing | Near real-time | TMC, road operators, FCD, Crowdsourcing data, CCTV | HR-CR |
| ITA – Port of La Spezia | Do not report RW | | | | | | | | | |
| NLD-Ams | Contractor & RA report RW | | | | | | | | | |
| SWE- | Do report RW | | | | | | | | | |
| SVN | RC, LC and Events are part of RW process, see table 1 | | | | | | | | | |

*Table 5: PDV - Road closure & Lane closure – General Information*

| PDV Site | How do you rate your RW Quality | E2E process effectiveness | RC/LC Validation Approach | Validation Method used today? | RC/LC Quality Metrics Used | How do you receive feedback on Q? | How do you maintain RW info | Navigation Service Performance | RC/LC Key Gaps | RC/LC Main Improvement needs |
|---|---|---|---|---|---|---|---|---|---|---|
| BEL-Flanders | | This is part of the core business of our traffic center | Ad-Hoc | | | | | Sometimes, unclear | Latency on detection of incidents | combining multiple data sources (via AI), adding SP data |
| BEL-Antwerp | RC and Events are part of RW process, see table 2. LC currently not implemented. | | | | | | | | | |
| FIN-Tunnel roads | High | This is part of the core business of our traffic centre | None | | | | Separate web-service and Phone calls to contractors to confirm status of ongoing work | Google, TomTom and Here are using our traffic announcement data and it is also available for DFRS community. | Latency on detection of incidents or reason | Improvement of the validation |
| FRA-Med | | | | | | | | | | |
| FRA-Herault | | | | | | | | | | |
| FRA-Nice | | | | | | | | | | |
| HR CR | High | Partially automated, relies on operator validation | Combination of manual validation and FCD-based validation | Traffic monitoring + FCD + operator confirmation | | Directly from users via HAK (Croatian Automobile Club) | From our contractors for the maintenance works via internal RAMS system. | 3333 | Lack of automated validation | HR-CR |
| ITA – Port of La Spezia | | Fully manual | | | | | | No | No digitalization, fully manual | |
| NLD-Ams | High | Good | None | | | No SP feedback, IDEA tool will be used | | The Dutch NAP transfers the data | | |
| SWE | | Good | | | | Sporadically directly from end users | Phone calls to contractors to confirm status of | RC's are shown, LC's not | Validation | |

| PDV Site | How do you rate your RW Quality | E2E process effectiveness | RC/LC Validation Approach | Validation Method used today? | RC/LC Quality Metrics Used | How do you receive feedback on Q? | How do you maintain RW info | Navigation Service Performance | RC/LC Key Gaps | RC/LC Main Improvement needs |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ongoing work | | | |
| SVN | High | Good | none | | | | RA monitoring | WAZE OK,<br><br>Others sometimes unclear | Validation | Improvement of the validation |

*Table 6: PDV - Road closure &/ Lane closure –Validation Summary*

## 5.3 PDV E2E process & architecture

As part of the PDV activities outlined in Annex A – Key observations from the PDV's, all PDV's have documented their current end-to-end (E2E) data process and architecture using a common MIRO template (https://miro.com/app/board/uXjVGHYOPRc=/). The E2E process is described as a sequence of detailed steps, covering the full data lifecycle, including source collection, publication, validation, merging, quality improvement, transformation, storage, distribution, consumption, and feedback and monitoring. For each step, PDV's have specified the main action performed, the responsible owner and role, detailed source information (including content related to road works, road closures and lane closures), processing characteristics, outputs, transfer mechanisms, update frequency, and an assessment of the step's effectiveness. Each step is also evaluated using a simple status indicator (working well, needs improvement, not working well), with a clear explanation of gaps, missing elements and dependencies towards the next step in the flow.

This detailed and harmonised description of the current E2E processes across PDV's allows a structured analysis of strong points and gaps in existing architectures, processes and tools. Based on this analysis, it becomes possible to identify which gaps can already be addressed using approaches applied successfully by other PDV's, and which strong practices can be generalised and documented in this deliverable as recommended common methods for validation, data quality improvement and process optimisation.

In addition to the current E2E process, PDV's are also asked to describe their target or "wishful" E2E process, representing the desired future architecture that is realistic to achieve within the project timeframe. By comparing the current and target E2E flows, missing steps, capabilities, methods or tools become clearly visible. This comparison provides direct input for defining improvement actions, prioritising developments, and identifying which additional methods, tools or partnerships are required to reach the target state. Together, the current and target E2E process descriptions form a key foundation for the gap-closing solutions and common methodologies described in this document. From these E2E architectures, we have distilled 4 “success stories” which can serve as best practice examples to other PDV’s. These are outlined in the next chapter 6 below.

## 5.4 High level summary of maturity of PDV’s

Based on these survey results and the detailed Key Observation per PDV (see chapter 13) current maturity of PDV’s can be summarized as:

### 5.4.1 Most Mature

**Netherlands (NDW / Amsterdam / Helmond)**

- Strong **centralized ecosystem (NDW Backbone + Daisi + MELVIN)**
- Advanced **multi-source integration** (FCD, public data, Service Provider data)
- Use of **algorithms (IDEA)** for validation and reliability scoring
- Emerging **feedback loops and confidence scoring**
- Clear move toward **automation and operational tooling**

### 5.4.2 Highly mature

**Croatia**

- Well-structured **multi-layer validation (RCNUP + SCNUP-DC)**
- Strong **governance and central control**
- Good **real-time validation and operational processes**
- Already integrating **FCD and moving toward automation**

Slightly more manual than NL, but **very solid operational maturity**.

### 5.4.3 Moderately mature (good foundations, but gaps)

- **Belgium (Flanders)** → strong operational setup, but still **human-dependent**
- **Finland** → good systems, but **validation not yet robust / limited FCD use**
- **Spain** → strong data coverage, but **incomplete reporting + manual dependency**

- **Sweden / Slovenia** → solid processes but **limited automation & feedback loops**

- **Fance -** France → strong national-level systems and standards in place, but fragmented implementation across regional and local authorities, with limited harmonization and feedback loops

### 5.4.4 Early-stage / low maturity

- **Cyprus** → still **paper-based**, digitalization ongoing

- **Italy (La Spezia)** → **administrative, non-digital**, no structured data flows

The biggest differentiators between PDVs are: **level of automation, use of external data , (FCD, feedback) and ecosystem integration**

# 6 Best Practices

## 6.1 Be-Warned (Be-Mobile)

### 6.1.1 Be-Warned Platform

The Be-Warned platform, as depicted on Figure 2, has the potential to connect numerous real-time data sources with millions of drivers. Next to incorporating regular public and private data sources, including floating car data, probe vehicle data, traffic counts, traffic events, and so on, a key differentiator is the platform's living feedback loop: every second, thousands of road users validate, confirm or correct events, making each alert smarter, more precise and more relevant. The platform could serve two primary target groups, Automotive/OEMs and Driver Apps, while also directly supporting road authorities, emergency services and millions of road users. Combined, they are able to generate and distribute high-quality safety intelligence for a multitude of use cases, including RTTI, SRTI and beyond.

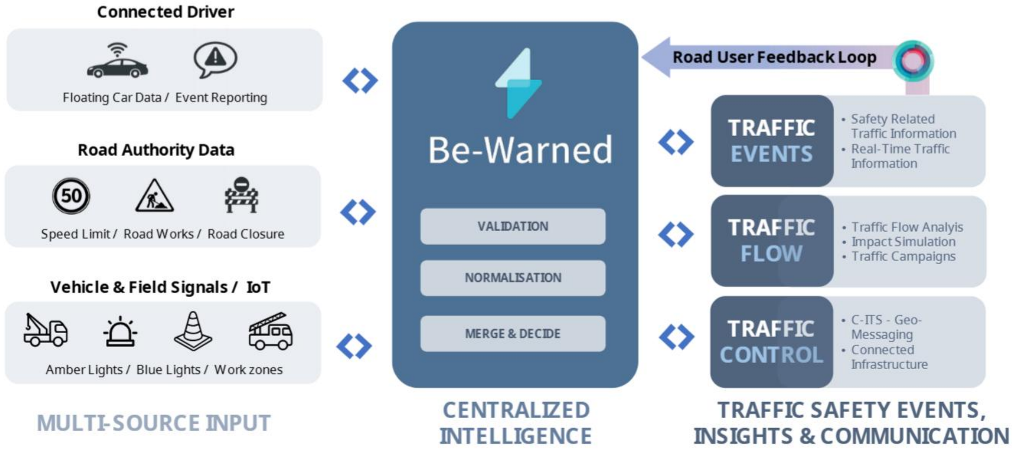



*Figure 2: Be -Warned: Traffic & Safety Platform centralizing and normalizing multi-source traffic data into trusted traffic & safety intelligence for drivers and road authorities*

### 6.1.2 Objectives

To achieve this mission, Be-Warned focuses on four core objectives:

1. Give every driver, regardless of vehicle brand, app or region, access to verified alerts for hazards such as stopped vehicles, construction zones, wrong-way drivers, blue/amber lights, slippery roads and dynamic speed limits.

2. Provide driver apps and vehicle systems with harmonized, validated safety alerts without the need for their own data pipelines. Through millions of road user feedback loops, apps benefit from continually improving data quality and higher user trust and engagement.

3. Offer OEMs a single platform that provides Euro NCAP-aligned safety warnings, by absorbing the complexity of data sourcing, filtering and standardization. By doing so, car manufacturers can focus on delivering reliable in-car driver assistance without building their own safety-data ecosystem.

4. Unite all mobility stakeholders in one scalable hub that harmonizes National Access Points (NAPs), road authority feeds, OEM data and road user feedback into a single safety stream and reduce fragmentation by allowing every stakeholder to benefit from a shared safety intelligence layer that becomes more accurate with every trip.

### 6.1.3 The Method

Be-Warned is designed for generating real-time situational awareness messages.

*Dynamic & static traffic events*

Be-Warned detects and distributes both dynamic and static traffic events. A core feature is the ability to receive and broadcast community position data, enabling the platform to automatically generate safety-critical events. In traffic, seconds matter and its low-latency (<300 ms) and high-frequency (up to 10 Hz) processing engine guarantees almost instant sharing across the ecosystem, while map-based filtering ensures only relevant drivers are alerted. Be-Warned also integrates with safety infrastructure such as V-16 beacons, arrow trucks and traffic lights, providing a complete real-time view of the road network. This makes it ideal for use cases such as emergency vehicles approaching, dynamic hazards, or fast-changing traffic conditions.

*Value-added Ecosystem*

In forming strong partnerships with governments and road operators and delivering feedback directly integrated with their data processing chains, Be-Warned increases the value of the entire ecosystem. By increasing the coverage, correctness and therefore value of (publicly) available data sources we stimulate greater adoption, leading to increased user feedback and thereby accelerating the flywheel.

### 6.1.4 Technology

The core of the platform exists of two basis modules: the merge & decide module and the road user feedback module.

*Merge & Decide Module*

The Be-Warned platform serves as a central platform where “single point of truth” datasets are published for service providers and end users. Because these datasets are fed by a mixture of governmental sources, private parties, and user-generated reports, multiple sources can report the same road event. The Merge & Decide technology ensures that such overlapping reports are intelligently combined and that only the most reliable consolidated event is delivered.

The Merge step groups similar source events based on three criteria: the event type, spatial proximity, and temporal overlap. Event types are clustered into predefined groups (e.g., accidents, works, slow vehicles, weather hazards). If a newly reported source event matches an existing group, it is added; otherwise, a new group is created. If one event fits multiple groups, those groups are merged.

The Decide step determines which source within a group is the most authoritative. Each use case defines a ranking of trusted data sources—typically DATEX II (from road operators or national access points) at the highest level, followed by Road User Feedback (RUF), editorial feeds, and other sources. Only the highest-ranked source event in a group becomes the published consolidated event. This avoids duplications and improves accuracy, especially regarding event location. Blocklisting ensures that events can be suppressed when they are outdated, corrected, or actively dismissed by trusted entities. When no sources remain for an event, it is removed.

*Road User Feedback (RUF) Module*

Road User Feedback (RUF) is a mechanism that allows end users and service providers to actively contribute real-time information about road events. At the core of Be-Warned is a vast network of driver communities: millions of connected drivers who share and validate real-time road information. The platform incorporates a self-regulating feedback loop, allowing community members to contribute reports, validate events, and collectively enhance road safety. This community-driven approach boosts accuracy, increases coverage, and makes the system more resilient. The continuous feedback loop refines detection models and improves accuracy with every trip, making every alert smarter and more relevant.

To guarantee reliable RUF information, each message receives a score depending on the reporter's reliability level: from 1 (unreliable individual user) up to 6. When the total score surpasses a predefined threshold, the platform creates and publishes a new event. Thresholds depend on various parameters, including e.g., road type, where higher-class roads require a score of 6, while lower-class roads can deal with lower scores. Overall, the RUF technology provides a structured, quality-based mechanism for crowdsourced validation, correction, and initiation of road events.

*Other technology components*

The platform works independently of the underlying connectivity technology, and operates natively over 4G/5G mobile networks, ensuring low-latency communication and highly reliable data exchange, even in dynamic environments. Be-Warned can be deployed as a cloud-based solution or in an on-premise environment, with full support for modern communication technologies such as WebSockets, JSON, and Protobuf. This flexibility allows organisations to tailor the system to their own security, scalability, or compliance requirements.

Through its backend-to-backend API, Be-Warned provides access to valuable business intelligence, allowing to extract insights, monitor performance, and optimise operations. Thanks to a Bring-Your-Own-Data (BYOD) approach, organisations can easily add their own datasets and enrich the Be-Warned ecosystem with proprietary information.

To support daily operations, Be-Warned offers out-of-the-box monitoring dashboards that give clear oversight of all events, user activity, and safety trends. This combination of intelligence, automation, and real-time communication makes Be-Warned a powerful tool for managing and improving road safety at scale.

### 6.1.5 Results and Evaluation

The basic technology of the Be-Warned platform, including the Merge & Decide and Road User Feedback modules, was already used and evaluated in several projects. Below we give the main outcomes of the Mobilidata project (Flanders, BE) and the VM-IVRA project (NL), as both projects are also linked to RTTI use cases like roadworks and road closures.

*Mobilidata*

Mobilidata is a Flemish C-ITS (Cooperative Intelligent Transport Systems) program that develops and deploys digital services such as intelligent traffic light priority, road hazard warnings, roadworks information, environmental zones and multimodal travel support. By creating a trusted data ecosystem and promoting interoperable standards, Mobilidata ensures that mobility information can flow seamlessly between road operators, vehicles, apps and infrastructure, ultimately improving safety, traffic flow and user experience across Flanders.

The Be-Warned platform has been foundational in the success of the Mobilidata ITS deployment. The safety alerts presented are met with a higher than 80% acceptance rate by end users, with similar results for the driver comfort information presented when approaching connected traffic lights. We have measured an average speed decrease between informed and non-informed drives through blind A/B testing of 4 km/h, showing a clear benefit of the information and manner of presentation to the drivers.

The next figures show some statistics from a recent evaluation during a morning from 7:00 till 13:00 in time intervals of 10 minutes, within the Flanders region. Figure 3 shows the number of active events reported by end users that were not in any other source. This shows the strength of road user feedback, otherwise these events were not available in the road safety data.


*Figure 3: Number of active events reported by end users that were not in any other source (Mobilidata)*

Figure 4 shows the number of active upvotes and downvotes that we include in RUF calculations, which is fluctuating around 1000 in the considered time interval. For events that were earlier reported, road users can confirm (upvote) or deny (downvote) their existence. In this way, we can increase the reliability of reported events, or unsubscribe events that were recently ended.

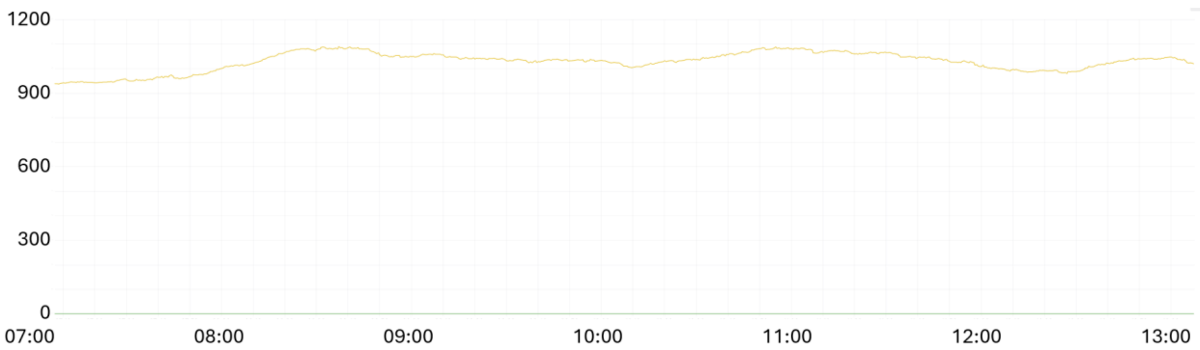



*Figure 4: Number of active upvotes and downvotes that we include in RUF calculations (Mobilidata)*

Figure 5 shows the number of unique event points from all sources (green) vs. the number of events in the created output (yellow). This graphs highlights the relevance of the merge & decide technology, as it consolidates the number of events to less than half of them.

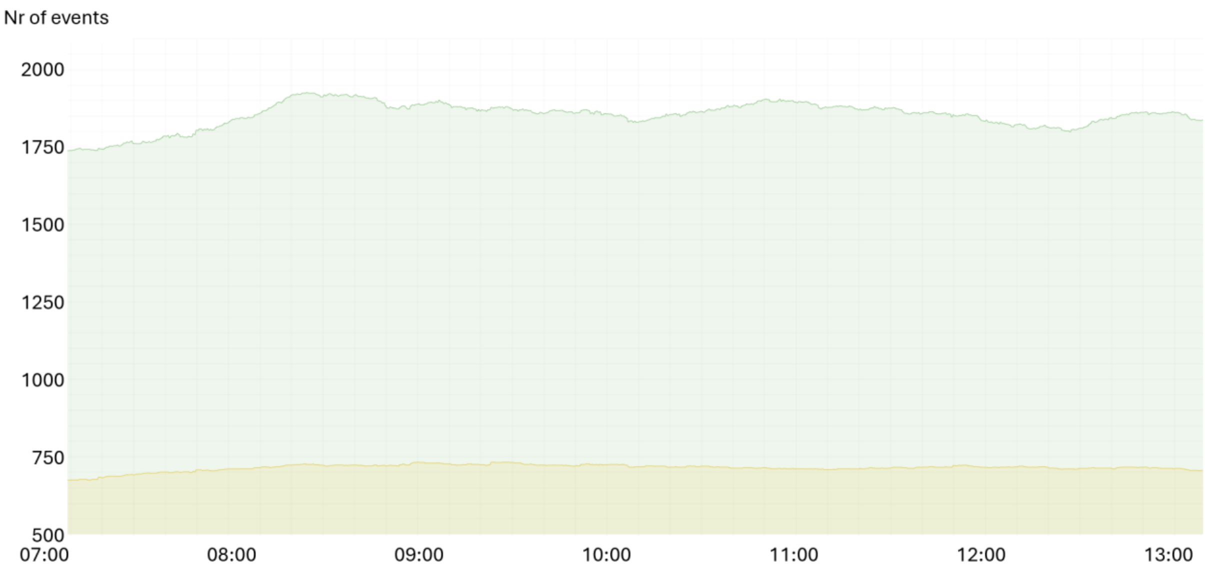



*Figure 5: Number of unique event points from all sources (green) vs. number of events in the created output (yellow) (Mobilidata)*

When comparing Figure 5 with Figure 3 , we can conclude that the number of events solely available by RUF (60-70 per 10 minutes, as shown in Figure 3) represents ca. 10% of the consolidated event stream (600-700 per 10 minutes, as shown in the yellow graph in Figure 5), once more emphasizing the power of having access to immediate road user feedback.

*VM-IVRA*

Within the VM-IVRA programme, Be-Mobile - primarily via its Flitsmeister application - played an important role as service provider implementing and validating in-car traffic management services. Be-Mobile demonstrated that digital traffic management information can meaningfully reach and influence large numbers of road users. One of the clearest quantitative results comes from the environmental and zero-emission zone service. Because VM-IVRA made standardized (DATEX-II) zone information available nationally, Be-Mobile/Flitsmeister integrated this data and now sends over 1 million environmental-zone warnings per month to its users.

Be-Mobile actively participated in the pre-announcements service, and contributed to warnings on roadworks, tunnel closures, incident notifications, school zone, and weather restriction alerts. These tests helped clarify data quality requirements, user-impact expectations, and the value of public-private cooperation. Using the Be-Warned technology, including road user feedback, improvements were made in data quality and timing, which are critical conditions for real-world usefulness. Results also showed that digital pre-trip and on-trip warnings can significantly reduce the need for roadside signs in locations with high digital reach.

#### 6.1.6 Conclusions

Be-Warned has the potential to become a European-wide road safety hub, supporting real-time warnings for local hazards and other traffic information data. Its merge & decide technology ensures a continuously up-to-date and unique data stream of numerous event types originating from multiple data sources. Incorporating road user feedback from millions of connected drivers allows to rapidly validate, confirm and correct the road events. The platform will result in fewer secondary crashes, faster reactions and one unified, reliable source of truth for every road user. The potential impact was already illustrated in projects like Mobilidata (Belgium) and VM-IVRA (The Netherlands). These projects give evidence to the road safety potential if the generated real-time warnings can reach the road user in an effective way, enabled by connecting a whole ecosystem of vehicles and driver companion apps.

The Be-Warned technology was extensively used and evaluated in real-life deployments in Belgium and the Netherlands, but it is available for all European countries and is connected to data sources and driver communities from a growing number of countries. Such a safety hub should continuously evolve to ensure every road user, regardless of app, vehicle or region, can travel more safely through trusted, timely and accurate alerts.

## 6.2 Netherlands – MELVIN (NDW)

MELVIN (Reporting Disruptions in the Infrastructure of the Netherlands) is a national application for entering, coordinating and publishing planned road works and events across road, water and rail networks. It provides one unified national standard for reporting disruptions, ensuring that infrastructure managers, contractors and service providers all work with the same up to date information. The aim is to support safe, predictable and efficient mobility by improving coordination, reducing traffic impact and making reliable data available as open data to navigation providers and other stakeholders.

### 6.2.1 Challenges that led to the development of MELVIN

1. **Fragmented systems and data**
   In the past, different authorities used various unconnected systems, leading to inconsistent data and coordination gaps. Creating one national standard required harmonizing these disparate processes and technologies.
2. **Multi-party coordination**
   Road works and events often involve several road, waterway or railway authorities. Automating conflict detection—such as overlapping detours or works along designated diversion routes—posed significant technical and organizational challenges

3. **Integration with external systems**
   Connecting the various systems, including systems for underground utilities required alignment of data models and workflows.
4. **Nationwide adoption**
   Gaining broad participation from municipalities, provinces and contractors was a major challenge. Today, approximately 85% of municipalities use MELVIN, Other applications for road planning have a connection with MELVIN, so our NDW backbone platform can be used as a hub.

### 6.2.2 Results

- **Established national standard Datex II since 2018**
  MELVIN has grown into a nationwide system hosting hundreds of daily entries on road works and events.
- I**mproved coordination and reduced disruptions**
  Automatic conflict analysis helps authorities identify overlapping works and conflicting detours, resulting in better planning and minimized traffic impact.
- **Public transparency and open data availabilit**y
  Published reports are visible on the public MELVIN website and shared as open data with navigation companies (e.g., TomTom), improving traveler information and traffic management.
- **Digital pre-notification (since 2024**)
  Infrastructure managers can submit digital pre-notifications for planned works directly in MELVIN, further improving preparation and communication.

### 6.2.3 Recommendations for Other Countries

- **Adopt a data-driven governance model**
  Engage infrastructure managers, contractors and service providers throughout design, implementation and improvement processes.
- **Prioritize open data and transparency**
  Publishing work notifications as open data enhances the ecosystem and allows market parties to innovate.
- **Ensure broad system integration**
  Integrate with systems for road, rail, waterways and underground infrastructure to provide a complete operational picture.
- **Support adoption through regional guidanc**e
  As in the Netherlands, regional coordinators can help onboard organizations and improve data quality.

### 6.2.4 Future Plans

- **Expansion of digital pre-notification workflows**
  Further standardization and automation of processes for all infrastructure authorities.
- **Improved data integration**
  Strengthening connections to underground utility systems, waterway management and new mobility domains.
- **Enhanced data quality managemen**t
  Use of validation tools and feedback mechanisms with navigation providers.
- **Advanced impact assessments**
  Incorporating traffic models and historical data to forecast disruption impact more accurately.
- **Probability assessment**
  NDW is creating an algorithm based on Floating Car Data to assess the likeliness of planned road works actually happening (IDEA).

## 6.3 Netherlands – Backbone & Daisi (NDW)

The **NDW Backbone** is the new real time data system of the National Road Traffic Data Portal (NDW). It serves as a **central hub** in which traffic data from *an increasing number of sources* is:

- collected
- combined
- validated
- enriched
- distributed

These sources include emergency control rooms, road authorities, service providers, vehicle data, road sensors, contractors, and road inspectors. The result is a single, uniform view of incidents and traffic situations.

Where **NDW Backbone** brings these sources together and digitally distributes them, another NDW tool named **Daisi** makes the 1s and 0s tangible and visible**.**

### 6.3.1 What does the backbone do?

<u>1. Consolidating and standardizing incident reports</u>

The backbone merges reports from various systems (crowdsourced, PVD/vehicle data, road inspectors, etc.) and converts them into **one uniform DATEX II message**. This makes the information more reliable and more useful for road authorities and service providers.

2. Faster detection of incidents

Crowdsourced reports can be received **up to 5 minutes earlier** than traditional reports from road authorities, enabling faster warnings.

3. Increased road safety

Drivers react significantly better to early warnings (see also [Snellere meldingen en alerter op weg dankzij in-car meldingen | Nationaal Dataportaal Wegverkeer):]()

- **42% brake earlier** after receiving a digital alert
- **52% feel more alert**

This improves both incident handling and safety.

4. Better real time view of road conditions

By combining data related to:

- Detection
- Incident management
- Handling times
- Mitigation measures

NDW can create the “best possible view of the road,”

### 6.3.2 How is the backbone used in practice?

**For NDW and road authorities**

- Faster insight into incidents
- Uniform, high quality messages for all partners (RWS, provinces, municipalities)
- Improved foundation for traffic management and incident handling

**For market parties**

NDW provides the enriched and consolidated information as an **open data feed**, enabling apps and navigation services to deliver better warnings and routing.

**For road users**

- Earlier warnings
- Better situational awareness
- Fewer surprises on the road

### 6.3.3 What does Daisi do?

1. Daisi receives incident information from the NDW Backbone and enriches the 1s and 0s with operational data needed for traffic-/incident managers to put this incident data to practice. Daisi displays received data on a map and in a (sortable)table with added information like the local road authority, road numbers, start-time of the incident, number of updates received, and so on for all its users. Think of it like a Common Operational Picture. This provides users with a full overview of all active incidents in the NDW Backbone enriched with all the operational information they need to bring incidents to a fast and successful conclusion.

2. Besides showing information Daisi features the possibility for uses to provide operational ***hot-feedback*** to the data shown. Whenever a user owns valuable information (for example seen on camera in a traffic centre), they have the possibility to input this into Daisi for it to be send to NDW Backbone. This way Daisi users can provide NDW with reliable information about incident location, category, handling status and estimated duration of the incident and its effects.

The combination of **NDW Backbone** with its extensive data collection and **Daisi** providing valuable operational feedback on this data sets up a strong foundation for unmatched data quality.

### 6.3.4 Future developments

With NDW Backbone and Daisi working together to get the best quality incident information, NDW is also looking to extend this principle to other data sources. Planned and currently active road works are two examples. By combining sources in NDW Backbone about planned road works and for example measured traffic from external systems, NDW can determine whether the planned road works are actually active on the road. Daisi also provides users with a tool to deliver feedback about the shown data and adjust parameters like start/end time, start/end location of the road closure etc.

### 6.3.5 Confidence Score

All sources combined in NDW Backbone are given a NDW Confidence Score (see also section 6.7 on Trust Levels). This score (between 0 and 100) is determined, for example, by the reliability of the data source, the activity measured on the source, lessons learned for previous cases, and a predictability algorithm. This score provides operational users in e.g. Daisi insight into the actuality of the shown data and the possible need to act on shown events. In case of accidents, it gives users a priority in handling incidents. In case of road works, it shows how certain the data provider (in this case NDW) is about the actuality of the given data.

#### 6.3.6 Summary

The **NDW Backbone and Daisi together are the central engine behind real time traffic information in the Netherlands**.

They link, combine, and enrich traffic data from a broad range of sources and convert them into consistent and, most importantly, reliable information. This leads to faster detection of incidents, better information services, and demonstrably safer driving experience.

### 6.4 Netherlands – IDEA

#### 6.4.1 IDEA improves information on road closure

Information about road closures has been available as open data for years. Service providers can use this data in their route advice, but many service providers are reluctant to use data from public road authorities. The reason is that the data is not always up-to-date or accurate. To improve the quality of this information, Amsterdam and NDW - the National Access Point for this data in the Netherlands - launched the IDEA project. This initiative uses floating car data and algorithms to verify road closure information.

#### 6.4.2 Planning tools and open data

Most road authorities in the Netherlands use tools like SPIN, LTC, and MELVIN to plan and coordinate road works.All the data from these tools end up in the same endpoint: the Dutch roadworks and road closures (MELVIN) Database. These tools help minimize disruptions, such as drivers encountering multiple road works in a short distance. Additionally, these planning tools make basic roadwork data available as open data. Service providers can use this data in navigation services to guide road users around active road works.

#### 6.4.3 The Challenge: last minute changes and inaccurate data

In practice, the planning data is not always accurate. A contractor usually receives a timeslot to do the work and within that slot the road is not closed all the time. This means that if authorities share the planning of the road works, it’s not an accurate representation of the state of the road. Additionally, road works don’t always go as planned. Factors like traffic conditions, weather, or resource issues can cause delays, early starts, or shifts in work locations. These last-minute changes are often not updated in planning tools and therefore don’t appear in the open data. As a result, navigation and fleet management systems may work with outdated information.

This can lead to road users being unnecessarily rerouted or encountering unexpected closures. Over time, service providers lose trust in the data and stop using it, even though it has significant potential value. A similar issue arises with data on infrastructure like tunnels and bridges—if opening times are outdated, the information becomes unreliable.

### 6.4.4 Intelligent Data Exchange Alliance

To improve the reliability and quality of road closure and detour information, Amsterdam launched a project with NDW. We received funding for this from the European Commission through the Meridian project.

Co-funded by the European Union

MERIDIAN

Fostering digitalisation of the mobility system

They asked The Hague, the Province of North Holland and Rijkswaterstaat as an advisory commission, to make sure the new solution would not just work for roads in Amsterdam. IDEA aims to:

1. Validate planned and communicated road restrictions using an algorithm and provide a reliability score. Service providers can integrate this additional information into their navigation systems.
2. Give road authorities insight into the information they delivered to the NDW. The system shows when the road was supposed to be closed and when it was actually closed. This helps road authorities monitor contractors without going to every location to see it.

NDW collaborated with Dat.mobility, MAPtm, and Lynxx to develop the validation algorithm and feedback tools.

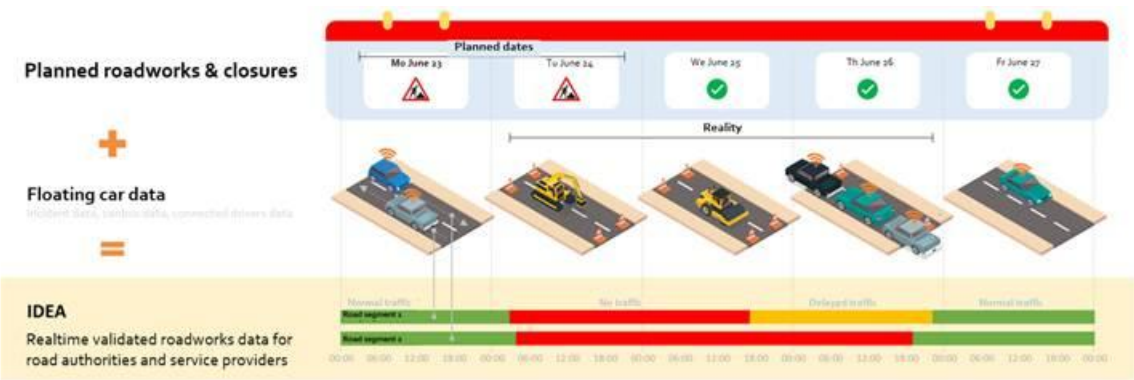



*Figure 6: Process IDEA*

### 1. The validation algorithm

The algorithm uses floating car data (FCD) which is bought through a national tender, which provides real time insights into traffic flow, including travel times and speeds. For each road restriction, the algorithm analyzes traffic conditions before and after the planned road works. It compares real time FCD with historical traffic profiles to detect deviations caused by road works (rather than incidents like breakdowns). The algorithm is trained to recognize patterns, enabling it to validate whether road works are proceeding as planned.

One challenge is that FCD availability varies throughout the day and is less reliable on lower-priority roads. In order to make sure that this won't become problematic, an additional smoothing algorithm was created. Thanks to training, the algorithm can now reliably determine whether closures on these roads align with the plan.

### 2. Insights for road authorities

In order to better inform road authorities, the team has also created a dashboard for road authorities. This dashboard displays validation results from the algorithm, highlighting areas where there are discrepancies.

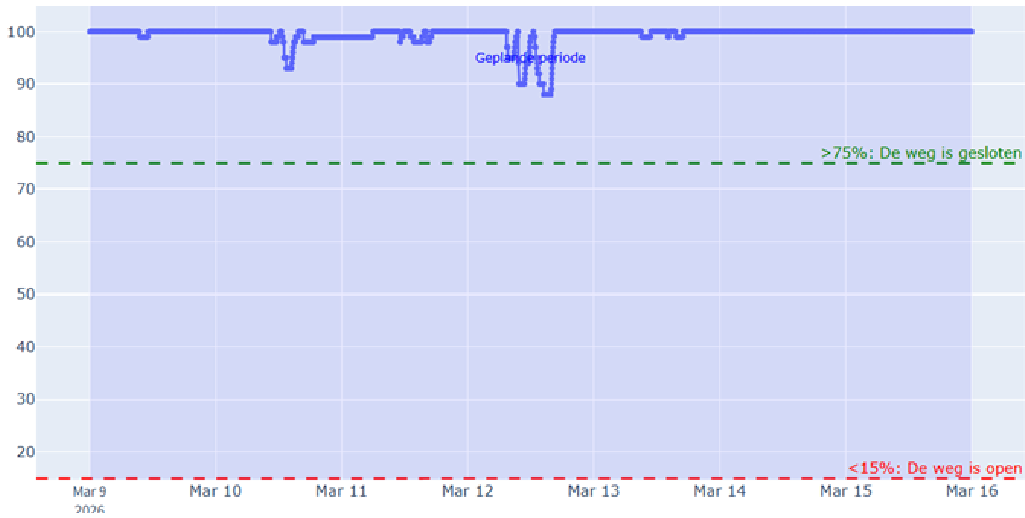



*Figure 7: Chance of closure over time - Translation of Dutch text in the screenshot: Planned period, >75%: The road is closed, <15% The road is open*

## 6.4.5 Next Steps

The algorithm is now ready for large-scale deployment in the Netherlands at the NAP level, improving road works and road closures data for all road authorities in the Netherlands. Service providers can receive the data. Additionally a similar setup was launched in Helsinki and Porto.

In the coming phase, the IDEA project will focus on improving the algorithms and minimizing mistakes.

## 6.5 Spain - Connected Cones

The Connected Vehicle Platform (DGT 3.0) is the platform of the Dirección General de Tráfico (DGT), which integrates, standardizes and makes mobility information available in a truthful, open and free way. This platform is available to all actors that are part of the mobility ecosystem, whether they contribute and/or consume information. The platform is built through use cases, one of which is "Connected Cones. Construction Zones".

The connected cone is an **IoT device** with an automatic **yellow flashing light** that transmits its exact location, enabling the identification of **road works on the road**. The "virtual visibility" provided by the NAP, allows us to **warn** drivers about the presence of road works before they approach the affected area.

### 6.5.1 Objectives

- Increase road worker safety.
- Prevent accidents caused by changes in road conditions.
- Optimize traffic flow by allowing vehicles to anticipate the situation.
- Provide high-quality information: exact location of the affected section and immediate activation/deactivation of the incident.
- Make communication of the start and the end of road works simpler and faster.
- Also usable for signalling in case of accidents and for implementing traffic control measures by traffic authorities.

### 6.5.2 Regulatory Framework

The following existing regulations have been considered to develop the legal framework for the connected cone:

- **Commission Delegated Regulation (EU) 886/2013** of 15 May 2013 supplementing Directive 2010/40/EU of the European Parliament and of the Council regarding data and procedures for the provision, where possible, of **minimum universal traffic information related to road safety**, free of charge for users.
- **Commission Delegated Regulation (EU) 2022/670** of 2 February 2022 supplementing Directive 2010/40/EU regarding the **provision of real time traffic information services** throughout the European Union.
- **Resolution of 22 February 2021** establishing the **National Access Point (NAP)**.

The work carried out in this area has been resulted in the **Resolution of 17 January 2025** of the Directorate General for Traffic defining the **protocol and format for sending data to the National Access Point regarding road works**, using connected cones.

### 6.5.3 Technical Characteristics of the Connected Cones

Among others technical characteristics:

- Light beacon mounted on **TB-6 delineation element**, designed for quick dismantling and storage.
- The cone must comply with **UNE-EN 13422:2020**.
- Maximum positioning error: 2.5 meters.

### 6.5.4 Data Model

The data model use for sending information to the Connected Vehicle Platform is the following:

| Atribute | Data type | Description |
|---|---|---|
| actionId | Text | Unique identifier for the event, where an event is defined as each signalled operation, recorded from switch-on to switch-off |
| beaconId | Text | Unique identifier for the cone (e.g. the MAC) |
| beaconTypeId | Integer | Identifier for the status of the connected cone. Possible values: 1 = Start, 2 = Intermediate, 3 = End, 4 = Single. |
| timestamp | Datetime UTC | Date and time taken from the GPS in UTC format at the moment the event was generated. |
| lon | Double | Longitude of WGS 84 coordinates where the event was generated. |
| lat | Double | Latitude of WGS 84 coordinates where the event was generated. |
| HDOP | Integer | DOP value to determine the quality of the GPS data in metres. |
| deviceTypeId | Integer | Identifier of the type of device from which the data is sent. Possible values: 1 = cone |
| deviceUseTypeId | Integer | Identifier of the usage type of the device sending the data. 3 = Infrastructure |
| eventTypeId | Integer | Identifier of the event type. Possible values: 1 = On, 2 = Active, 3 = Off. |
| beaconDown | Boolean | Fallen cone identifier. Possible values: false = cone in normal position, true = cone fallen. |

*Table 7: Attributes of the Connected Cones - All attributes are mandatory.*

### 6.5.5 Publication and Consumption Process

The complete publication and consumption process in the Connected Vehicle Platform is defined in the following service scheme:


*Figure 8: complete publication and consumption process in the Connected Vehicle Platform*

# 7 Quality Assurance

## 7.1 Role of Quality Assurance in the PDV Framework

Quality Assurance (QA) within each PDV entails the continuous monitoring, validation, and improvement of data quality across the full data lifecycle. QA acts as the overarching process that connects validation activities, KPI calculation, and data quality improvement into a structured continuous improvement loop.

QA consists of three core components:

- **Validation**, where data is systematically checked against rules and ground truth sources
- **KPI calculation**, where data quality is quantified using standardized indicators
- **Data quality improvement**, where identified issues are corrected and structural improvements are implemented

These components form a continuous cycle: validation activities generate KPI values, KPI analysis identifies weaknesses and quality improvement processes address these weaknesses, leading to measurable improvements in subsequent validation cycles.

This ensures that data quality is not only controlled but continuously improved over time.

KPI values are derived from validation processes and serve as the primary mechanism to:

- Detect data quality issues
- Prioritise improvement actions
- Measure the effectiveness of quality improvement activities

## 7.2 Governance and Operational Setup

Each PDV shall establish a structured Quality Assurance (QA) process responsible for both operational validation and continuous data quality improvement.

QA governance shall ensure clear ownership of data quality across validation, KPI monitoring, and quality improvement activities.

The QA process is responsible for:

- Executing validation methods (see Section 7)
- Calculating and monitoring KPI performance (see Section 7.4)

- Identifying and analyzing recurring discrepancies
- Defining and implementing data quality improvement and improvement actions
- Reporting KPI evolution over time

Minimally, the QA process shall include:

1. **Data Quality Lead**
   Responsible for KPI monitoring, discrepancy analysis, and coordination of validation and improvement actions

2. **Technical Data Specialist**
   Responsible for implementing validation rules, data comparison logic, automation, and system integration

Recommended:

3. **Traffic Domain Expert**
   Responsible for interpreting operational inconsistencies and supporting complex validation decisions

In smaller PDVs, roles may be combined, but responsibilities must remain clearly assigned.

## 7.3 Quality Improvement Objectives

During the pre-deployment phase, each PDV shall define clear and measurable quality objectives. At minimum, PDVs shall aim to achieve and maintain an RTTI 5-Star Rating of at least 3 stars per data source and improve this rating over time.

## 7.4 Quality assurance process flow

The QA process follows a continuous improvement cycle:

1. **Validation execution**
   Data is validated using feasibility checks, desk based and ground truth validation checks

2. **KPI calculation**
   Validation results are translated into measurable KPIs (e.g. correctness, completeness, timeliness) which translate into a source-level rating. Additionally, the following *progress KPI's* shall be monitored:

   - Percentage of correct events
   - Percentage of missing events
   - Percentage of false positives

- Average publication delay
- Percentage of timing corrections
- Percentage of geometry corrections

3. **Issue identification**
   KPI analysis highlights structural weaknesses and recurring discrepancies

4. **Data quality improvement and corrective actions**
   Targeted improvements are implemented, including data corrections, process changes, or integration of additional data sources (e.g. FCD, RUF)

5. **Re-evaluation**
   KPI values are recalculated to measure improvement and ensure effectiveness of the implemented actions

This cycle is continuously repeated to ensure progressive improvement of data quality.

# 8 Validation KPI Calculation Framework

This chapter describes the validation and measurement component of the Quality Assurance framework. It provides a set of generic validation method building blocks that can be applied by PDVs to assess the quality of road works-related data, including road works, road closures and lane closures, before, during and after deployment.

These building blocks are technology-agnostic, reusable, and can be combined depending on the maturity, tooling and operational context of each PDV. The objective is not to prescribe a single validation implementation, but to provide validated methodological patterns that PDVs can select, adapt and integrate into their own end-to-end (E2E) processes.

Validation outcomes shall be translated into KPI values, which enable structured quality monitoring and form the basis for the quality improvement and continuous improvement activities described in Chapter 8. It is recommended that each PDV describes in its PDV Plan which validation methods it will adopt in its current process, starting from the common PDV Plan Template.

## 8.1 Role of Validation in the Quality Assurance Cycle

Validation is the component of the Quality Assurance framework that determines whether data correctly reflects real-world conditions and whether it can be safely and reliably used in downstream navigation and traffic services. Validation is therefore not only a control mechanism, but also the basis for measurable data quality management.

Within the Quality Assurance cycle, validation serves three main purposes:

1. to detect errors, inconsistencies and missing information at event and source level;
2. to generate measurable KPI values that quantify data quality;
3. to provide the evidence base for corrective actions, data quality improvement and structural improvement.

Validation is therefore closely linked to KPI measurement and continuous improvement. It is the mechanism through which data quality issues become visible, measurable and actionable.

## 8.2 Validation Objectives and Principles

Validation ensures that road works, road closure and lane closure data correctly reflect real-world conditions and can be safely used by Service Providers. The objective is to establish and maintain data that is correct, complete, timely and consistent, to detect and correct deviations between planned, published and actual situations, and to support reliable use in navigation and traffic services.

Validation is a continuous activity that runs throughout the full lifecycle of an event. Planning information is checked before activation; active status and applied restrictions are monitored during execution; and correct deactivation and restoration of normal traffic conditions are verified after completion.

Validation activities are aligned with RTTI quality attributes and partly rely on independent ground truth sources. These may include road authority validation systems, contractor information, field observations, Floating Car Data (FCD), Road User Feedback (RUF), and other relevant private or crowdsourced sources. Where appropriate, such sources may also be used as additional validation inputs even if they are not published.

Validation shall follow the following principles:

- **Traceability**: validation decisions must be explainable and auditable;
- **Repeatability**: validation methods should be documented and consistently applied;
- **Proportionality**: effort should focus on high-impact and high-risk cases;
- **Automation where feasible**: routine checks should gradually be automated;
- **Human review where needed**: manual review should remain available for exceptions, low-confidence cases and complex situations;
- **Continuous improvement**: validation results should not remain descriptive, but should directly feed into quality improvement activities.

## 8.3 Validation Process Overview

The proposed validation process is finally summarized in the following flow diagram:

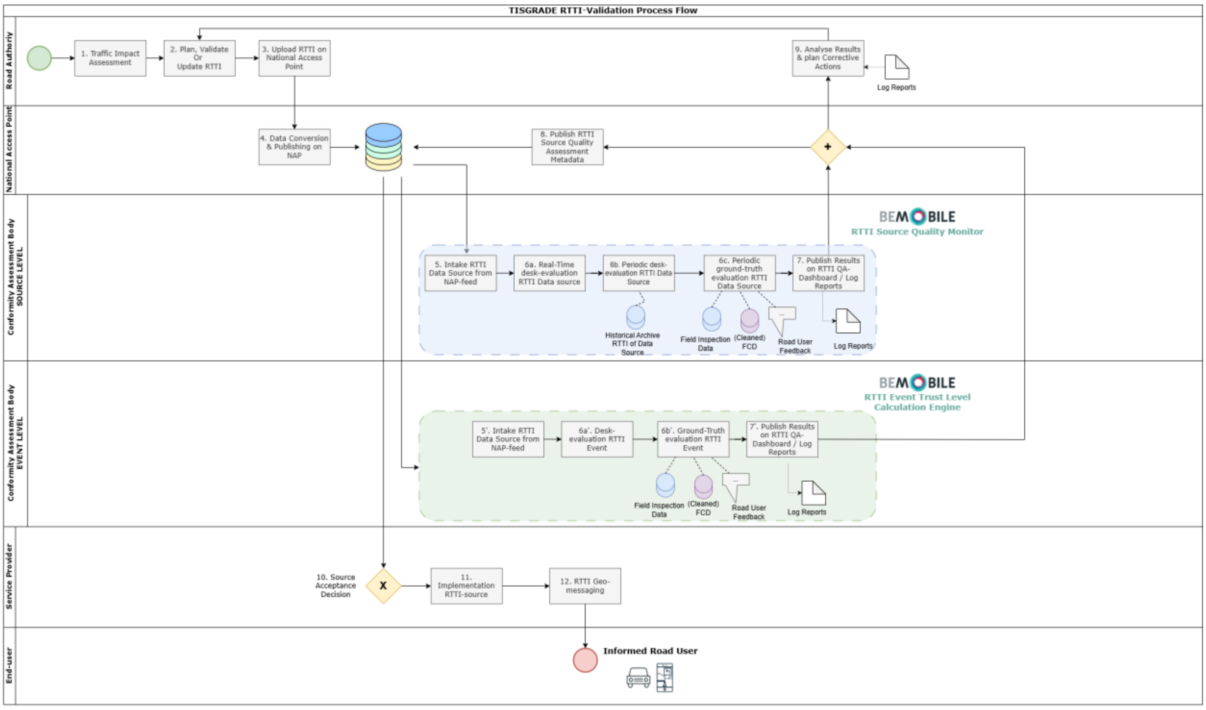



*Figure 9: Proposed Validation Process*

The high-level validation process consists of a sequence of operational and analytical steps through which data is created, published, validated, assessed and improved.

Description of the different components:

| | Process Step | Description | Tooling |
|---|---|---|---|
| 1 | Traffic Impact Assessment | The Road Authority conducts a Traffic Impact Assessment to evaluate the effect of a planned traffic change on network flow and capacity. Using traffic management models or tools based on historical FCD and route planning technology, diversion patterns and congestion impacts on surrounding roads are estimated. Based on these insights, the Road Authority defines and issues appropriate traffic management measures. | Be-Mobile - Flowcheck - ReFlow module |
| 2 | Plan, Validate or Update RTTI | The Road Authority uses a dedicated tool with a graphical user interface to spatially capture and configure Real-Time Traffic Information (RTTI). The tool allows the Road Authority to define and detail traffic events or restrictions across the road network, specifying | Be-Mobile - Traffic Events Editor |

| | | | |
|---|---|---|---|
| | | attributes such as validity dates, time windows, affected vehicle categories, and other relevant parameters. | NDW - Melvin Tool |
| **3-4** | Upload RTTI on National Access Point<br><br>Data Conversion & publishing on National Access Point | The Road Authority uploads or links the RTTI data feed to the National Access Point (NAP), making the traffic information discoverable and accessible to authorised parties, including Service Providers.<br><br>The NAP can fulfil this role in two ways. In its **passive** form, the NAP acts as a metadata portal, registering the feed's location and access details so that Service Providers can discover and independently connect to the RTTI source. In its **active** form, the NAP acts as a centralised data directory that aggregates and redistributes the traffic information directly to Service Providers. In the latter case, the NAP may additionally perform data format conversions to ensure compatibility with the consumption requirements of downstream parties. | NDW - Melvin |
| **5** | Intake RTTI Data Source-feed from NAP-feed | The RTTI Quality Monitor continuously ingests the RTTI data source feed from the National Access Point (NAP), accumulating traffic information over a defined time period in order to support a continuous, objective assessment of the data source quality over time, rather than a point-in-time snapshot. | Be-Mobile - RTTI Quality Monitor |
| **6a** | Real-Time Desk Evaluation of RTTI Data Source | The RTTI Quality Monitor performs continuous, real-time desk evaluations of the incoming RTTI data feed, executing automated checks on each incoming data delivery. These checks include data format compliance, validity, syntax validation, and other immediate quality indicators that can be assessed at the level of individual feed updates as they are received. | Be-Mobile - RTTI Quality Monitor |
| **6b** | Periodic Desk Evaluation of RTTI Data Source | The RTTI Quality Monitor performs periodic desk evaluations of the RTTI data source, assessing quality characteristics that only become apparent when the feed is analysed over a longer time period. Examples of such checks include the distribution of traffic events across functional road classes, the consistency of event identifiers over time, and the update cycle of the feed — evaluating whether new events are delivered at a regular and expected cadence.<br><br>The applied checks are conducted against a defined quality assessment framework. Several such frameworks exist within the industry, including the TISA 5-star rating methodology, though the choice of framework remains subject to alignment with the relevant Road Authority and applicable regulatory context. | Be-Mobile - RTTI Quality Monitor |
| **6b** | Periodic Ground-truth Evaluation of RTTI Data Source | The RTTI Quality Monitor complements the desk evaluation by periodically validating the RTTI data source against real-world conditions. This ground-truth evaluation can be conducted using one or more of the following methods, applied independently or in combination:<br><br>**Method 1 — FCD-based Validation** | Be-Mobile - RTTI Quality Monitor<br><br>Be-Mobile - Traffic Events |

| | | | |
|---|---|---|---|
| | | The RTTI data source is validated against a cleansed Floating Car Data (FCD) stream. The presence or absence of probe vehicles can confirm real-world traffic conditions, such as the existence of roadworks or road closures. Additionally, static road speeds defined in the RTTI feed can be evaluated against FCD-derived speeds, such as V85 speed observations, to assess their accuracy and currency.<br><br>**Method 2 — Road User Feedback (RUF)-based Validation**<br><br>The RTTI data source is evaluated against feedback provided by end users, who assess the correctness and accuracy of the published traffic information, including aspects such as location precision. This method carries the precondition that the RTTI feed is already being published and disseminated by a Service Provider, and that the Service Provider has implemented the capability to collect and process Road User Feedback.<br><br>**Method 3 — Independent Ground-Truth Dataset**<br><br>A statistically representative ground-truth dataset is captured independently of the RTTI source. This reference dataset is used as an objective benchmark against which the quality and accuracy of the RTTI feed can be systematically assessed, without reliance on either probe data or end-user input. | Editor (Method 3) |
| **7** | Publish Results on RTTI QA-Dashboard | The RTTI Quality Monitor publishes the outcomes of both the desk and ground-truth evaluations on the RTTI QA Dashboard, making the results available per RTTI data source for consultation by NAP and/or the Road Authority. | Be-Mobile - RTTI Quality Monitor |
| **5'** | Intake RTTI Data Source-feed from NAP-feed | The RTTI Event Trust Calculation Engine continuously ingests the RTTI data events from a source feed with the goal to assess their quality on an individual level. | Be-Mobile - RTTI Event Trust Level Calculation Engine |
| **6a'** | Desk-Evaluation RTTI Event | The RTTI Event Trust Calculation Engine continuously evaluates individual RTTI events as they are received, executing automated checks on each event within the incoming data feed. These checks include event-level format compliance, attribute validity, syntax validation, and other immediate quality indicators that can be assessed at the level of the individual event. | |
| **6b'** | Ground-Truth Analysis RTTI Event | Evaluates individual RTTI events from a source against supporting data streams — including Floating Car Data, Road User Feedback, and third-party event reports — to assess event presence, positional accuracy, and data reliability. Based on this multi-source cross-validation, feedback is provided, reflecting the degree to which independent sources confirm or contradict the reported event. | |

| | | | |
|---|---|---|---|
| **7'** | Publish Results through RTTI Log Reports | The RTTI Event Trust Calculation Engine publishes the outcomes of both the desk and ground-truth analysis through log reports, making the results available on individual event level for consultation by NAP and/or the Road Authority. | |
| **8** | Publish RTTI Source Quality Assessment Metadata | The aggregated quality assessment score is published as metadata on the National Access Point (NAP), making the evaluation outcome discoverable alongside the RTTI data source for consultation by authorised parties such as Service Providers. | |
| **9** | Analyse Results & Plan Corrective Actions | The Road Authority consults the RTTI QA Dashboard and reviews the quality assessment results for its RTTI data source(s). Optionally, detailed report logs of the data feed may be made available alongside the aggregated quality scores, providing granular insight into the performance of individual components of the feed. This is particularly relevant where a feed is composed of multiple underlying sources at the Road Authority level, allowing the Road Authority to pinpoint quality issues at a sub-feed level and target corrective actions with greater precision.<br><br>Where results indicate shortcomings in data quality, the Road Authority defines and plans appropriate corrective actions to address the identified issues. This step feeds back into **Step 2 — Plan & Update RTTI**, closing the quality improvement loop and ensuring that the process supports continuous improvement of the RTTI data source over time. | |
| **10** | Source Acceptance Decision | Based on the consolidated quality assessment score published on the NAP, the Service Provider makes an informed decision on whether to subscribe to and distribute a given RTTI data source. The aggregated score provides an objective, independently established insight into the quality of the source, removing reliance on self-reported or unverified claims by the data provider.<br><br>Depending on the applicable regulatory or contractual framework, this decision may be either discretionary or obligatory. Where a defined quality threshold has been met and demonstrated, the Service Provider may be required to incorporate the source into its service offering, ensuring that end users benefit from verified, high-quality traffic information. | |
| **11** | Implementation RTTI Source | The Service Provider integrates the accepted RTTI data source into its platform and service infrastructure, establishing the necessary technical connections and configurations to enable reliable and continuous ingestion of the traffic information feed. | Be-Mobile - Be-Warned Real Time Traffic Information -and Safety Hub. |

| | | | |
|---|---|---|---|
| **12** | RTTI Geo-messaging | The Service Provider delivers the relevant RTTI to the end user at the right time and in the right place, based on the user's current or anticipated location and the temporal validity of the traffic information. This targeted, location- and time-aware dissemination ensures that the Road User receives actionable traffic information that is directly relevant to their journey, contributing to the ultimate goal of an **Informed Road User**. | Be-Mobile - Be-Warned Real Time Traffic Information -and Safety Hub / Flitsmeister |

*Table 8: Description of the different components of the validation process*

## 8.4 KPI Framework for validation and continuous improvement

Validation processes shall be traceable and auditable, allowing PDVs to understand, monitor and improve data quality over time. Automation should be applied wherever feasible to handle routine checks, while human review remains necessary for exceptions, low-confidence cases and complex situations.

Key Performance Indicators (KPIs) are a central component of this validation framework. They serve both to **measure data quality** and to **drive continuous improvement**.

### 8.4.1 Definition and Structure of KPIs

For each data quality attribute to be assessed (e.g. correctness, completeness, timeliness, consistency), one or more clearly defined KPIs shall be established within a structured validation process.

Each KPI shall include:

- a precise definition of the attribute being measured
- a transparent measurement methodology
- a clear calculation formula
- defined data requirements (e.g. sample size, time window, reference sources)

This ensures that all stakeholders measure and interpret data quality in a harmonised and comparable way.

Two general categories of KPIs can be distinguished:

- **Desk validation KPIs**
  These are calculated using the information available in the data feed itself or in a historical database of feed updates.

- **Ground truth validation KPIs**
  These are calculated by comparing the data feed against external ground truth data sources that reflect real-world conditions.

Typical KPIs may include:

- percentage of correct events
- percentage of missing events
- percentage of false positives
- average publication delay
- percentage of timing corrections
- percentage of geometry corrections

These KPI values represent the measurable outputs of the validation process.

### 8.4.2 Role of KPIs in Continuous Improvement

Beyond measurement, KPIs play a central role in driving data quality improvement. They are used by PDVs to:

- identify weaknesses in data quality
- prioritise improvement actions
- evaluate the effectiveness of implemented changes over time

KPI results shall therefore be actively used as input for data quality improvement and process optimisation, as further described in Chapter 8.

The quality improvement approach may include, where relevant:

- the use of ground truth sources to validate, correct or confirm data
- the integration of Floating Car Data (FCD), user feedback, crowdsourced data or Service Provider feedback as additional validation signals
- the preparation of tools and processes to receive, interpret and process incoming feedback signals
- the use of rules, plausibility checks or algorithms to automatically or semi-automatically improve data quality
- cooperation with third parties providing data quality improvement or quality improvement services

At this stage, PDVs are not required to describe detailed algorithms or technical implementations. However, they shall clearly describe the intended approach, responsibilities and expected contribution to data quality improvement.

## 8.5 Validation levels

Within the high-level process flow shown in Figure 9, two complementary validation levels can be distinguished:

### 8.5.1 Event-Level Validation

At event level, individual events are validated, typically in real time or near real time. The purpose is to assess whether a specific event is plausible, correctly located, timely, and operationally consistent. Event-level validation supports day-to-day quality control and, where implemented, may result in event-specific individual score or trust level.

### 8.5.2 Source-Level Validation

At source level, the entire data feed is validated as a whole, typically on a periodic basis. The purpose is to assess structural data quality and to generate measurable KPI values for correctness, completeness, timeliness and consistency.

Source-level validation can be further divided into:

- **Feasibility checks**, typically performed by the Road Authority on the platform where initial event data is collected.
- **Source assessment or rating**, typically performed by the NAP or another central quality monitoring component on the source as it would be published.

Together, event-level and source-level validation support both operational quality control and KPI-based quality assessment.

In the following sections, we discuss both levels.

## 8.6 Validation on event level: Trust Levels

Validation scores at the event level are also called **trust levels**. These are defined as a quantitative measure of trust which the data feed supplier or the NAP supplier has in each individual event of the data feed**.** For example, a feed of roadwork data may contain a specific event of planned road works, entered by a local subcontractor. This event and its data (such as road works location, start and end time,…) may receive a trust level of e.g. 40%, where a maintenance road works event that was entered by the national road authority may be given a higher trust level (or even 100% right away).

The goal of this additional attribute in data feeds is that service providers can get an idea of the *probability* that the details of events are correct. This way, rather than e.g. only publishing events with a trust level of 100%, the data feed supplier/publisher can include events after a preliminary indication and update the details (and thus trust level) of the event continuously, before as well as after publication and/or start of the event. Additionally, this allows data feed suppliers to perform **data fusion** and include sources which may be, on their own, not immediately 100% trustworthy, but by combining multiple of these kinds of sources together, as well as official sources, a higher level of completeness can be attained.

Note that, **after the start of the event**, a primary source for trust level updates is user feedback. This feedback may arise from users who were supplied with information about this same event, from this same data feed, letting the source know e.g. that the location is not fully correct. But also, this feedback can come from users who have no information at all, or information from an unknown source.

An applied example of trust levels can be found in The Netherlands, where the NAP supplier NDW uses the software tool Daisi (see section 5.1) to automatically calculate trust levels for SRTI (e.g. traffic incidents). However, we realize that this requires a high level of (data) maturity in the PDV ecosystem, not to mention the right software tools. This is currently not feasible for most PDV's, and we recommend focusing first on the (automatic) validation process of data feeds without any trust levels. This concept can be kept in mind, and as the project progresses, it can be assessed whether (some) PDV's can build this kind of software (or at least a correct trust level calculation methodology). If this is the case, trust level evaluation can easily be included later in the validation process.

When trust levels are available in SRTI data feeds, an additional process can come into play when multiple sources contain information about the same event: **merge and decide** logic. This is an algorithmic process which takes into account the different trust levels provided by the respective sources and makes a final choice about what properties of the event will be chosen to be used in end-user services. Merge and decide logic can be performed e.g. by the NAP before final publishing, but also by the service provider (e.g. when sources from multiple NAPs are combined).

### 8.6.1 Validation of Service Provider Use of Published Data

In the Netherlands, the General Directorate for Public Works and Water Management (Rijkswaterstaat, RWS), the road authority responsible for national roads, frequently deal with large road works projects. In these projects they noticed that, although money is being spent on SP's (or intermediary parties), they still receive many complaints from road users about missing or incorrect road works in e.g. navigation apps. This led to the development of the tool Route Radar, which can historically log the routing advice from different SP's on a specific OD relation. By comparing this information with the data feeds from NDW (the NAP) one can find discrepancies between public data and the info to road users. For example, it is a common finding that SP's use the preliminary start timings and locations of road works (as they were entered in the planning phase), even if these are updated closer to the start. End timings on the other hand, are usually detected through FCD (e.g. when a road or lane opens up and probes are detected once more).

Route Radar gives very relevant insights into event level reliability for both SP's (do end users receive correct information) and for Road Authorities/NAPs (which data and how is it being communicated to the end user), and we advise for it to be used in the quarterly TISGRADE discussions between RA's and SP's.

## 8.7 Validation on Source Level – Feasibility Checks

The second validation level, at the source level, starts with a set of practical validation methods that PDV's can apply directly in daily operations to check the feasibility of road works, road closures and lane closures. The methods are designed to be combined and referenced consistently across pilots and applying them will automatically lead to a higher score for the data feed in the final validation step at the NAP (see below).

### 8.7.1 Method V1 – Planning Data Pre-Check (Before Activation)

This method is applied when new or updated planning data is received. PDV's review the event in a map or list view and verify that the location, start and end time, expected impact, and affected lanes are provided and consistent. Conflicting or incomplete records are corrected where possible or returned to the data provider before activation.

### 8.7.2 Method V2 – Rule-Based Plausibility Check (Automatic First Line)

This method runs automatically during data ingestion or before publication and is used to detect obvious errors. PDV's should implement a limited, clear set of rules, such as:

- missing or invalid geometry
- start time after end time
- end time in the past for active events
- missing mandatory attributes (e.g. road identifier, event type)
- number of closed lanes greater than total lanes
- inconsistent status (e.g. “active” with no start time)
- overlapping events with conflicting restrictions on the same road segment

Critical rule violations should block publication, while non-critical issues should be flagged for review.

### 8.7.3 Method V3 – Active Status Monitoring (During Execution)

This method is applied to active events. PDV's monitor dashboards or reports that highlight outdated updates, overdue end times, missing status changes or inconsistent lane availability. Detected issues trigger follow-up actions such as requesting updates, correcting data or closing events.

### 8.7.4 Method V4 – Ground Truth Comparison

When authoritative reference data is available, PDV's validate published data against ground truth sources such as road authority or contractor systems. Validators compare data side by side, focusing on exceptions rather than all records, and verify location, timing, status and impact. Discrepancies are corrected or escalated to the responsible data provider.

### 8.7.5 Method V5 – Cross-Source Consistency Check

This method is used when multiple sources provide similar information or when no single ground truth exists. PDV's compare or overlay data from different sources and identify inconsistencies in geometry, timing or status. Conflicts are resolved based on predefined source reliability rules or operational agreements.

### 8.7.6 Method V6 – Spatial Validation

PDV's visually inspect event geometries on the road network and apply basic automated checks for alignment, overlaps and connectivity. Misaligned or incorrect geometries are corrected where possible or sent back to the data provider.

### 8.7.7 Method V7 – Temporal Validation

This method focuses on start and end times and update frequency. PDV's monitor for stale records, delayed updates and overdue end times using alerts or periodic reports. Actions include requesting updates, adjusting timings or automatically closing events.

### 8.7.8 Method V8 – Deactivation and Cleanup Check (After Deactivation)

After an event ends, PDV's verify that road works, closures or lane restrictions are correctly removed and that normal traffic conditions are restored. Lingering or stale records are corrected or closed.

### 8.7.9 Method V9 – Feedback-Triggered Validation (WP5)

User and service provider feedback is used as a validation signal. The Feedback architecture is still in design mode. However, how it flows now from the end user to the PDV, directly or over the NAP, the PDV's should ingest feedback. Preferable the removal of duplicates and noise, and group reports by location and time, should be done with tools at NAPs. And only repeated or consistent feedback triggers validation actions. These are confirmed using ground truth, authority data or other reliable sources before corrections are applied.

#### 8.7.10 Method V10 – Method to validate missing events

One of the outcomes of Method V4 is a list of events in the ground truth data that appear to be missing from the data feed. This list should be maintained over time and several feed updates, and analyzed in function of

- Correlation in event types of the missing events
- Correlation in location/times of the missing events

This analysis then leads to an identification of which type of events are generally missing, where, and when. This information can then be used to improve the data feed quality, either by coupling a new source or by going back to the data provider.

#### 8.7.11 Method V11 – Method to validate anomalies

By looking for strong correlations between the typical field values of validated events (e.g. duration, road type, type of event, etc.), strongly connected attributes can be determined. By adding these attributes of new events to the existing correlation plots, outliers can be quickly flagged as anomalies and thus possible errors. E.g.: a contractor enters a road works duration of 1 day to major works on a motorway, while the known correlation plots show this typically takes at least 5 days. This can be automatically flagged, leading to a manual verification of the entered information.

#### 8.7.12 Recommended Method Combination

In practice, PDV's should apply **Method V2** continuously as the first validation layer, use **Methods V3, V6 and V7** for operational monitoring, apply **Methods V4 or V5** to confirm detected issues, and use **Method V9** as an additional trigger or confirmation. **Methods V1 and V8** ensure clean activation and deactivation. Over time, stable checks should be automated while manual effort remains focused on exceptions and high-impact cases.

### 8.8 Validation on Source Level – Assessment/rating

In addition to validation by the Road Authority, source-level validation may also be performed by the National Access Point or another central quality monitoring component. At this level, the objective is to assess the overall quality of the published source as it is made available to downstream parties.

This type of validation is typically periodic rather than real time. It may include both desk validation and ground-truth validation, and should result in a consolidated view of source quality. Such assessments provide transparency to Road Authorities, support harmonized source evaluation, and may help Service Providers make informed decisions on source adoption.

Where applicable, the resulting source assessment may also be published as metadata alongside the source itself.

To ensure that KPIs for source level validation are measured consistently and based on sufficient and representative data, a structured approach with three consecutive phases is provided:

1. **Phase 1: Initial Data Collection Phase**
   Be-Mobile will collect the required data feed updates during the first months of operation to build the required historical databases. This involves data feeds from the NAPs *as-is,* with quality and specifications as they were before the project.
2. **Phase 2: Execution of manual validations**
   PDV's will execute their selected feasibility checks and log the progress over time. In parallel, the collected data during phase 1 will be used to perform manual example desk validations in accordance with the TISGRADE specifications.
3. **Phase 3: Automation of KPI Assessment**
   In parallel with phase 2, a tool will be made available that enables automated execution of the finally selected validation method on datasets of RW/LC. The finalization of the tool is envisioned in Q4 of 2026, This approach will:
   a. Ensure consistent KPI calculation of both desk and ground truth validation types
   b. Reduce manual effort
   c. Increase transparency and repeatability
   d. Support traceable and auditable reporting

By embedding clearly defined KPIs in a formal test protocol, the validation process becomes measurable, transparent, and comparable across providers, while maintaining alignment with RTTI quality principles.

In accordance with the three-phased approach given above, there is a need to select a *starting point validation method* with shared KPI's across all PDV's, which will serve as an **example working method** for manual assessments (phase 2). For this, we propose to use the TISA RTTI 5-Star Rating Specification.

## 8.9 Phase 1: Building a historical database of feed updates

During Phase 1, Be-Mobile has gathered access details for the relevant NAP data feeds (road works, lane/road closures, maximum speed limits) from the PDV's. Using these, the collection and storage of feed updates was started, in order to ensure a sufficiently large historical database for the calculation of historical desk validation KPI's in Phase 2.

## 8.10 Phase 2: RTTI 5-Star Rating as example method for manual validation

The **2022 EU RTTI Delegated Regulation (RTTI DR 2022/670), effective since 1 January 2025**, states that, on the one hand, road authorities must make their data available free of charge. On the other hand, Service Providers (SP's) are expected to use this data, provided that its quality is sufficient. As the regulation does not further define what "sufficient quality" entails, major Service Providers collaborated—initially within the NAPCORE framework—to establish a common understanding of data quality. They defined a set of requirements and agreed that a minimum threshold (commonly referred to as a 3-star level) represents the point at which a data source is considered usable by SP's.

This framework was subsequently shared with TISA, which further developed it into the TISA 5-Star Rating specification. In summary, while the EU regulation sets the principle, the concrete quality criteria—such as the 3-star minimum—have been defined and aligned among Service Providers and later formalized through TISA. **Further alignment with road authorities is still needed to ensure broad agreement and consistent adoption of these quality thresholds.**

Within the framework of TISGRADE, the TISA RTTI 5-Star Rating Specification is selected as the common example working method to validate datasets providing road works, road closure and lane closure information during the manual assessment (phase 2). During this phase, the 5-Star Rating serves as the primary KPI framework for assessing the quality of dynamic traffic data and forms the backbone of the validation process. **This is applied with the understanding that the specification may be further evaluated and refined, where necessary, to support broad adoption, while avoiding the need to introduce additional or parallel validation methods.**

### 8.10.1 Standardized Execution of the 5-Star Rating during the manual assessment phase

To ensure that the 5-Star Rating Specification is executed in a harmonized and consistent manner across all PDV's, the structured execution method is provided in the Annex.

The method translates the TISA 5-Star Rating Specification into a clear and practical operational procedure for PDV's. It defines precisely how each desk validation attribute must be measured, specifies the calculation logic and formulas each of these KPI's, and ensures a consistent and harmonized interpretation of the specification across all parties involved.

The method will be accompanied by a structured evaluation file. A designated member of the PDV team will execute the method and complete the file, for each relevant dataset/feed. Based on the entered KPI values, the file will automatically generate a **5-Star Rating value per source**.

### 8.10.2 Minimal Dataset Requirements for Manual Evaluation

A correct, standardized 5-Star Rating evaluation can only be performed based on sufficient **historical data**, as it was collected during Phase 1. A set of past data feed updates as they were originally published by the source is needed in an accessible database to calculate some of the desk validation KPI's. For the self-assessment validations in phase 2, a tentative **minimum of 100 events** is chosen as a starting point. This number is subject to evaluation and change.

## 8.11 Phase 3: Automation of the final validation methodology

Eventually, at the start of phase 3, **a final choice will be made on the KPI framework used for the development of automatic validation tools**. Using the TISA RTTI 5-Star Rating Specification as a working example in phase 2 will allow us to evaluate in detail whether this framework can serve this purpose.

This automatic tool will:

- Accept datasets in **DATEX I, DATEX II V2 or DATEX II V3 format**
- Process both source data and ground truth data
- Automatically calculate attribute KPIs
- Generate a validation score per source

This automation will represent a major improvement for the **continuous evaluation of dynamic data quality**, enabling:

- Faster execution
- Reduced manual workload
- Consistent KPI calculation
- Periodic re-evaluation
- Scalable validation across multiple sources

#### 8.11.1 Minimal Dataset Requirements for Tool-Based Evaluation

To ensure reliable automated execution, **Historical ground truth data** is needed. This is defined as verified real-world information reflecting the actual situation on the road network. These kinds of dataset will need to adhere to strict **minimum dataset characteristics** before being used for evaluating the related 5-Star Rating KPI's such as correctness, timeliness, completeness and consistency.

Ground truth sources shall provide authoritative and up-to-date information on the real-world status of road works, closures or lane restrictions. They should be maintained by organizations with operational responsibility, such as road authorities, traffic management centers or contractors executing the works. Information must be sufficiently timely, allowing validators to detect discrepancies between planned, published, and actual situations within an acceptable time window.

From a data perspective, ground truth sources must allow unambiguous identification of the affected location, including road segments and, where applicable, lanes. Temporal information, such as start and end times or activation status, must be extractable, even if approximate. The source must be accessible to the PDV validation team, either through direct system access, exports, or structured communication channels.

Ground truth sources may be digital systems, operational tools, or structured field observations. They do not need to be published or standardized (e.g. DATEX II), and they may include private or internal information that is used exclusively for validation. However, the provenance of the source must be known, and validation decisions based on ground truth should be traceable and auditable.

PDV's are expected to document which ground truth sources are used per data source and to assess whether these sources meet the minimum requirements before applying the validation methods described in the following sections.

# 9 Data Quality Improvement and Continuous Improvement Framework

## 9.1 Introduction: KPI-Driven Quality Improvement

Data quality improvement and continuous improvement activities shall be driven by the KPI results obtained through phase 3 of the validation framework described in Chapter 7. There, intermediate data feed evaluations (possible 5-Star ratings) will be executed. The difference (delta) between consecutive results will quantify the improvement achieved through the quality improvement processes.

This delta-based evaluation approach ensures that improvements in accuracy, timeliness, completeness, and consistency are objectively measurable and demonstrable. The chosen KPI framework for validation/rating thus functions not only as a validation mechanism, but also as a **performance monitoring and optimization instrument** throughout the lifecycle of dynamic traffic data.

### 9.1.1 Minimum QA Tooling Environment

KPI values provide an objective indication of where data quality issues occur, and which attributes of a data source require improvement. Based on these results, PDVs shall identify whether quality issues are related to:

- Structural aspects of the data source (e.g. format, coverage, update frequency). In this case, improvements can be achieved without introducing additional data sources, for example by:
    - improving data formats or mappings,
    - correcting workflows or update processes,
    - resolving systematic coverage gaps.

  or

- The quality of individual events (e.g. correctness, completeness, timeliness). In this case, additional data sources may be required to validate, enrich, or correct the data.

This latter case is illustrated in the following process flow and is further discussed below.

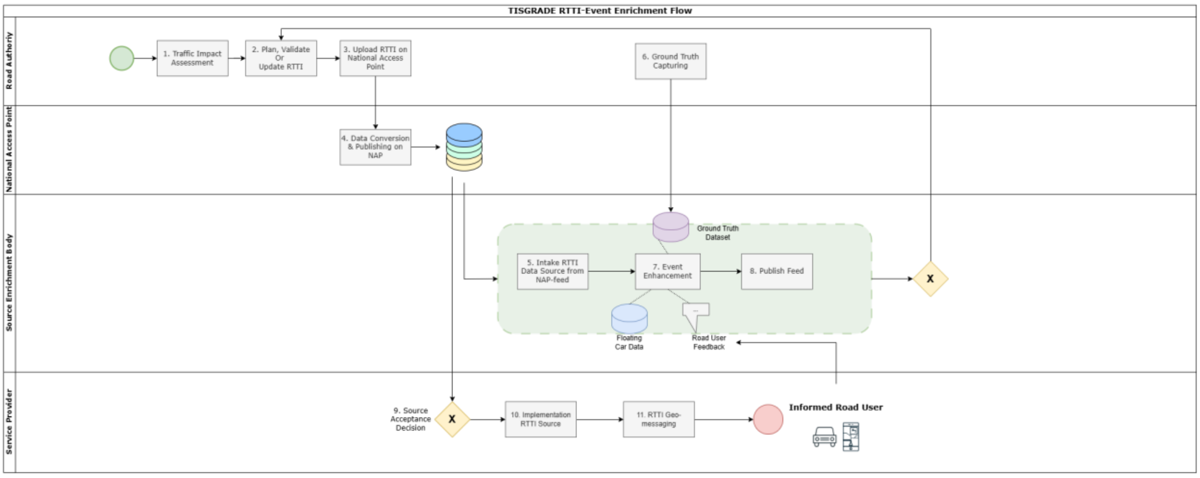



*Figure 10: Quality Improvement process flow*

Description of the different modules in the quality improvement process:

| | Process Step | Description | Tooling |
|---|---|---|---|
| 1 | Traffic Impact Assessment | The Road Authority conducts a Traffic Impact Assessment to evaluate the effect of a planned traffic change on network flow and capacity. Using traffic management models or tools based on historical FCD and route planning technology, diversion patterns and congestion impacts on surrounding roads are estimated. Based on these insights, the Road Authority defines and issues appropriate traffic management measures. | Be-Mobile - Flowcheck - ReFlow module |
| 2 | Plan, Validate or Update RTTI | The Road Authority uses a dedicated tool with a graphical user interface to spatially capture and configure Real-Time Traffic Information (RTTI). The tool allows the Road Authority to define and detail traffic events or restrictions across the road network, specifying attributes such as validity dates, time windows, affected vehicle categories, and other relevant parameters. | Be-Mobile - Traffic Events Editor<br><br>NDW - Melvin Tool |
| 3-4 | Upload RTTI on National Access Point<br><br>Data Conversion & publishing on National Access Point | The Road Authority uploads or links the RTTI data feed to the National Access Point (NAP), making the traffic information discoverable and accessible to authorised parties, including Service Providers.<br><br>The NAP can fulfil this role in two ways. In its **passive** form, the NAP acts as a metadata portal, registering the feed's location and access details so that Service Providers can discover and independently connect to the RTTI source. In its **active** form, the NAP acts as a centralised data directory that aggregates and redistributes the traffic information directly to Service Providers. In the latter case, the NAP may additionally perform data format conversions to ensure | NDW - Melvin |

| | | | |
|---|---|---|---|
| | | compatibility with the consumption requirements of downstream parties. | |
| 5 | Intake RTTI Data Source-feed from NAP-feed | The RTTI Quality Monitor continuously ingests the RTTI data source feed from the National Access Point (NAP), accumulating traffic information over a defined time period in order to support a continuous, objective assessment of the data source quality over time, rather than a point-in-time snapshot. | RTTI Event Quality Improvement Engine |
| 6 | Ground Truth Capturing | (**Optional Process Step**) In the absence of a Floating Car Data (FCD) set or Road User Feedback, the Road Authority may elect to independently capture an additional Real-Time Traffic Information (RTTI) ground truth dataset. This supplementary dataset is collected independently of the existing RTTI Source and is introduced into the data pipeline to improve the overall quality of the RTTI output that will ultimately be published on the National Access Point (NAP). | |
| 7 | Event Enhancement | In this process step, the Event Quality Improvement Engine attempts to enhance the RTTI Events as they are received from the source feed on the NAP. This enhancement can take multiple forms, ranging from the further refinement and adjustment of existing RTTI Events with respect to attributes such as positional accuracy, validity periods, and other relevant parameters, to the activation or deactivation of events based on substantiated reasoning derived from Floating Car Data (FCD), Road User Feedback datasets, or an independently captured RTTI ground truth dataset. | RTTI Event Quality Improvement Engine |
| 8 | Publish Feed | In this process step, the enhanced RTTI Events are streamed back out as a DATEX II-compliant feed, making the improved data available for consumption by the Road Authority or the NAP. | RTTI Event Quality Improvement Engine |
| 9 | Source Acceptance Decision | Based on the consolidated quality assessment score published on the NAP, the Service Provider makes an informed decision on whether to subscribe to and distribute a given RTTI data source. The aggregated score provides an objective, independently established insight into the quality of the source, removing reliance on self-reported or unverified claims by the data provider.<br><br>Depending on the applicable regulatory or contractual framework, this decision may be either discretionary or obligatory. Where a defined quality threshold has been met and demonstrated, the Service Provider may be required to incorporate the source into its service offering, ensuring that end users benefit from verified, high-quality traffic information. | |

| | | | |
|---|---|---|---|
| 10 | Implementation RTTI Source | The Service Provider integrates the accepted RTTI data source into its platform and service infrastructure, establishing the necessary technical connections and configurations to enable reliable and continuous ingestion of the traffic information feed. | |
| 11 | RTTI Geo-messaging | The Service Provider delivers the relevant RTTI to the end user at the right time and in the right place, based on the user's current or anticipated location and the temporal validity of the traffic information. This targeted, location- and time-aware dissemination ensures that the Road User receives actionable traffic information that is directly relevant to their journey, contributing to the ultimate goal of an **Informed Road User**. | |
| | Informed Road User | In this final step, the Road User receives the enhanced RTTI and in turn contributes back to the enhancement pipeline in three ways.<br>• First, by simply traveling with a connected device or vehicle, thereby passively generating Floating Car Data (FCD).<br>• Second, by actively providing feedback on reported events through upvoting or downvoting mechanisms.<br>• Third, by proactively reporting new events themselves. | |

## 9.2 Types of External Sources for Data Improvement

Data quality improvement on event level may rely on different types of external sources, each serving a specific purpose within the Quality Assurance framework.

### 9.2.1 Ground truth sources: improving the quality of existing events

Ground truth remains the primary reference for validation and improvement. It is used to:

- confirm correctness of events
- detect discrepancies
- identify missing or outdated events

Ground truth comparison is the most reliable mechanism for both KPI calculation and corrective action.

Within ground truth data, we distinguish three main types:

#### 9.2.1.1 *Road inspector data*

When a road inspector is dispatched, the data they collect can be seen as “true” ground truth data, with a trust level of 100%. The road inspector can use specialized tools with a geographical component to immediately digitize their collected data, ready to be used for quality improvement.

#### 9.2.1.2 *Floating Car Data (FCD)*

Floating Car Data can be used as a dynamic data source to detect:

- incorrect reopening of roads or lanes
- incorrect closing of roads or lanes
- potential missing events

For example, sustained low speeds or absence of probe vehicles may indicate the presence of an unreported roadworks or closure.

#### 9.2.1.3 *Road User Feedback (RUF)*

Road User Feedback refers to user input on **existing events**, for example:

- confirming that an event is correct (upvoting)
- reporting that an event is no longer valid (downvoting)

This type of feedback directly contributes to **event quality improvement** by using it to remove downvoted events or increasing the trust levels of upvoted events. In general, FCD and RUF receives a lower initial trust level compared to road inspector data, and an automatic prioritization algorithm can be applied to make the correct choice when fusing these sources.

Depending on the Service Provider setup, this feedback may be integrated into validation and quality improvement workflows at Service Provider level or transmitted back to the NAP.

### 9.2.2 Road User Sourcing: detection of missing events

Road users can provide **information about the presence of ”new“ events (missing from the feed)**, for example:

- reporting an unannounced road closure
- indicating unexpected congestion due to road works

Depending on the Service Provider and system architecture, this information may be transmitted back to the NAP.

## 9.3 Role of Tools in Data Source Quality Improvement

Several tools exist on the market that are capable of processing multiple data sources simultaneously, assigning a quality score per source and visualizing performance via dashboards. These tools allow continuous monitoring of source quality, comparison between sources and informed selection of data sources by Service Providers. Based on these quality scores, Service Providers may decide which sources to include in their services.

Depending on the business model between Service Providers, NAPs and Road Authorities, Road User Sourcing (new events) and/or Road User Feedback (event quality) may be fed back into these tools, often accompanied by corresponding trust levels. These inputs can then be used to further improve:

- event publication
- event updates
- event removal

To execute quality improvement effectively, the PDV must have:

- A structured environment for data comparison (SQL, Python, or equivalent) for the manual executions of 5-StarRatings
- Logging capability for detected discrepancies and corrections
- Monitoring dashboards or periodic reports for lifecycle and status checks

Without these minimum capabilities, validation cannot be systematic and KPI improvement cannot be measured.

## 9.4 Preparation for Integration of Feedback Mechanisms

PDVs shall prepare their systems and processes for the future integration of **trust levels** on event level, derived from structured Road User Feedback (RUF) and Service Provider (SP) feedback, as part of the Quality Assurance framework.

Although the detailed architecture for feedback exchange will be defined in WP5, PDVs must already ensure that their end-to-end (E2E) processes are capable of handling structured feedback in an efficient, scalable and qualitative manner.

At this stage, the exact feedback flow is not yet fixed. Feedback may be:

- delivered directly from Service Providers to PDVs, or

- transmitted indirectly via Service Providers, National Access Points (NAPs), or Road Authorities.

Regardless of the final architecture, PDVs shall prepare their systems to support flexible integration of these feedback channels.

### 9.4.1 Organizational and Process Preparation

Each PDV shall analyze its current E2E workflow and determine where feedback intake and processing (in order to obtain improvement) can be integrated.

This includes defining:

- where feedback will enter the system (technical entry point)
- who is responsible for reviewing and validating feedback
- how feedback will be logged, categorized and linked to existing events
- how feedback will trigger validation and improvement actions
- how corrections will be prioritized, implemented and tracked

Feedback shall not result in uncontrolled manual corrections, but in structured, traceable and auditable improvement actions.

### 9.4.2 Technical Preparation

PDVs shall assess and prepare the technical capabilities required for feedback ingestion and processing.

This includes the ability to:

- receive structured feedback messages (e.g. via API or file exchange)
- store feedback in a central registry
- link feedback to event identifiers, road segments or spatial-temporal clusters
- monitor recurring patterns and trends over time

These capabilities are essential to ensure that feedback can be effectively integrated into validation and quality improvement workflows.

### 9.4.3 Documentation in PDV Project Plan

Preparation activities shall be documented in the PDV Project Plan.

At minimum, the PDV Plan shall describe:

- the intended feedback intake architecture (aligned with WP5 developments)
- required system adaptations
- stakeholder coordination (Road Authorities, NAPs, Service Providers)
- the planned timeline for implementation
- the expected impact on validation processes and KPI performance

Once the final feedback architecture is defined in WP5, the PDV Plan shall be updated to include a detailed action plan for implementation.

By preparing organisationally and technically in advance, PDVs ensure that the future integration of Road User Feedback and Service Provider feedback can be embedded seamlessly into the existing validation and data quality improvement framework, without disrupting ongoing operations.

# 10 Validation & Quality Improvement Implementation

As outlined above, Deliverable D3.2 – D3.3 begins by providing a high-level overview of the current state of the art and the required actions for PDV's to improve their validation and data quality improvement processes. In addition, it describes the common methodology to be applied, including the use of the TISA RTTI 5-Star Rating, as well as best practices, complementary validation approaches, and supporting tools for quality improvement.

PDV's are expected to use this deliverable as the methodological foundation for developing their individual PDV Plans. In these plans, each PDV specifies in detail which datasets and sources will be addressed and which concrete validation and quality improvement actions will be implemented. The PDV Plan therefore describes the current PDV situation, the targeted end-to-end data flow, and the concrete actions foreseen over the next year (between April 26 and April 27), with a particular focus on the recommended actions identified in the previous chapter. This approach ensures that common validation, data quality improvement, and publication methods are applied consistently across all pilots.

Each PDV Plan starts with a clear description of the PDV ecosystem, including the operational area, objectives, and planned actions. It provides a structured overview of milestones and monthly planning and serves as a living document that is regularly updated throughout the project. The plan captures completed activities, upcoming actions, open issues, risks, required support, and detailed information on tests performed and their results. Annexes to the PDV Plan may include supporting documentation such as test protocols and test reports. Importantly, the PDV Plan shall clearly document the KPI values measured at the start of the task and the KPI values at the end of the implementation period, enabling transparent assessment of progress and measurable improvement.

Although the PDV Plan is not an official project deliverable, it is a strongly recommended working instrument designed to support efficient, structured, and coordinated implementation at PDV level. In close collaboration with the task lead, executed actions and planned next steps are periodically reviewed and documented to ensure alignment and continuous follow-up within the PDV ecosystem. As such, the PDV Plan will serve as the primary reference document for consolidating results and will form the basis for populating Deliverables D3.5 and D3.6.

## 10.1 Recommendations

The tables below shows the recommended actions for both RW and RC/LC, best practices and recommendations towards WP's 4 and 5 from the PDV's. The goal is to gather the processes that experience of the PDV's on processes that are already efficient and distribute towards all other project partners that might benefit from them.

| PDV Site | Improvements planned up to July 2027 | Recommended actions for your PDV | Best practices | Recommendations towards WP4/5 |
|---|---|---|---|---|
| BEL-Flanders | | Adding other data sources like data from SP's, SRTI-data from DfRS.<br><br>Introducing AI for combining different detections and smart filtering | Using GPS-equipped impact absorber trucks at roadworks. | |
| BEL-<br><br>Antwerp | Publish Datex-II<br><br>Collect feedback<br><br>Set-up process to evaluate and incorporate feedback in data. | Set up Large Language Model to scrape internal documents for information about RW/RC to trigger QC.<br><br>Set up pilot project with IOT connected cones or other connected signage to detect ground truth. | Start with a small quality data stream that is network-based. | |

| PDV Site | Improvements planned up to July 2027 | Recommended actions for your PDV | Best practices | Recommendations towards WP4/5 |
|---|---|---|---|---|
| CYP | Digitalisation of the Road Works Process<br><br>Enhancement of Data Validation Procedures<br><br>Data Publication via CyNAP | RA should provide training on the platform, and to Traffic Center operators. | (in future) Use of FCD and RUF (waze events) for validation<br><br>Use of *FixCyprus*, app for reporting RW | We need best practices and reference architectures for NAP-driven feedback loops, enabling structured data quality monitoring, bidirectional communication with service providers, and continuous improvement within the overall E2E process |
| FIN-roads | Adaption to use FCD and User Feedback for validation & Improvement. Better distribution of traffic over network, Improved routing in traffic disruption situations and temporary roadwork detours. | Automatic validation and correction of impact directions. Structured dialogue with and feedback from Service Providers. | Follow-up and analysis of how different Service Providers interpretate and use the information we provide gives valuable input to get an understanding of current issues and problems. | |
| FRA-Med | | | | |
| FRA-Herault | | | | |
| FRA-Nice | | | | |
| ITA – Port of La Spezia | | Short-term: define minimum data schema; formalize digital reporting; introduce completeness checks. | The Port Authority involves operational stakeholders in the information | |

| PDV Site | Improvements planned up to July 2027 | Recommended actions for your PDV | Best practices | Recommendations towards WP4/5 |
|---|---|---|---|---|
| | | Medium-term: integrate GIS and spatial model; implement PCS API; perform DATEX II mapping. | provision and circulation phases.<br><br>Well-established and working administrative workflows, to be evolved with digital data flows. Overlapping of planned works in principle should be avoided | |
| NLD-Ams | | Continue improving the NDW towards the service provider's process.<br><br>For the NDW, create a feedback loop towards the road authorities, for improving the quality of MELVIN data. | There are already some best practices implemented by NDW for the Netherlands, like IDEA and some quality checks.<br><br>From Amsterdam, it is recommended to enter roadblock data as much as possible into the NAP application, as much as possible at the source. | The city of Amsterdam would very much like to have a feedback loop from the service providers, regarding the quality of Amsterdam MELVIN data. |
| NLD-Helmond | Timeliness<br><br>Validation of actual start/end time<br><br>Feedback loop with NAP | To investigate the possibilities of MELVIN to support the improvement functions (see above).<br><br>To investigate if Helmond can improve the process, especially to demand feedback from the contractors for the start and end-times, to reach at least RTTI-5* L3. | Implementation of a process from design via approval to publication of the measures.<br><br>Good tooling (see MELVIN, LTC Andres and similar).<br><br>A clear distinction between responsibilities (systems) of the | A feedback loop on the road works measures, especially about the start and end-times is key, including the SP feedback to the NAP. |

| PDV Site | Improvements planned up to July 2027 | Recommended actions for your PDV | Best practices | Recommendations towards WP4/5 |
|---|---|---|---|---|
| | | | NAP and the local road authority. | |
| SWE | | Set requirements on contractors to deliver up-to-date data. Automatic validation. Structured dialogue with and feed-back from Service Providers | Follow-up and analysis of how different Service Providers interpretate and use the information we provide gives valuable input to get an understanding of current issues and problems. | |
| SVN | Collect feedback<br><br>Set-up process to evaluate and incorporate feedback data. | Optimization of the RW planning concerning mutual impact between different closures.<br><br>Upgrade and automation of the validation process.<br><br>Request the municipalities to use the national register. | It is beneficial if the road closure platforms are connected (or integrated) to the platforms that road managers use for maintenance planning of road network.<br><br>Road closure platforms should also enable the publication of standardised data on NAP's. However, it is also useful to be able to manually control the publication of this data if some corrections are needed. | We need feedback loop from the service providers. |
| ESP - DGT | To improve communication about the start of road works using connected cones. | | Use of IoT devices which provide accurate data. | |

| PDV Site | Improvements planned up to July 2027 | Recommended actions for your PDV | Best practices | Recommendations towards WP4/5 |
|---|---|---|---|---|
| | | | | |

*Table 9: Recommendations and best practices for RW*

| PDV Site | Recommended actions | Best practices | Recommendations towards WP4/5 |
|---|---|---|---|
| BEL-Flanders | Quality is dependent on employees' input and their awareness of the importance of data quality. | Equipping impact absorbers with GPS for 100% correct start locations of LC | |
| BEL-Antwerp | All RC and events are included in the RW process. LC currently not on the roadmap. | | |
| FIN-Tunnel | As we operate tunnel lane and road closures on main roads, we know when we have done actions and currently making traffic announcements with Datex2, we really would like to see how fast information is see by roadusers (impact). | Follow-up and analysis of how different Service Providers interpretate and use the information we provide gives valuable input to get an understanding of current issues and problems. | |
| FRA-Med | | | |
| FRA-Herault | | | |
| FRA-Nice | | | |
| HR CR | Focus on increasing automation in validation and real-time updates, with progressive integration of FCD and user feedback. | A multi-layer validation model (RCNUP + SCNUP-DC) combined with a unified data subsystem ensures consistency and control. Publication via the NAP | Feedback loop from the service providers is something that we need. |

| | | | |
|---|---|---|---|
| | | in Datex II v3 supports interoperability. | |
| ITA – Port of La Spezia | On the short-term, it is advisable to define mandatory closure fields and to progress on digitalization of the reporting process.<br><br>On a medium-term time frame, actions include to implement a traffic module to complement the PCS platform with a traffic control room; to start alignment with European ITS standards; and to manage temporal and spatial consistency checks. | Consolidated E2E flow, as a starting point for digitalization prior to publication.<br><br>Operational systems (PCS, TOS) information can be integrated with traffic information systems. Establish a shared minimum dataset across port road users typologies.<br><br>Define clear governance between Port Authority and operational stakeholders. | |
| NLD-Ams | | | |
| SWE | | Follow-up and analysis of how different Service Providers interpretate and use the information we provide gives valuable input to get an understanding of current issues and problems. | |
| SVN | Upgrade and automation of the validation process. | RC/LC data should be integrated in RW platform | We need feedback loop from the service providers. |

*Table 10: Recommendations and best practices for RC/LC*

# 11 Evaluation of Validation and Quality Improvement

At the end of T3.2 and T3.3 (after 12 months into the project), each PDV shall evaluate not only KPI improvements, but also the operational and technical maturity of its validation and quality improvement setup.

In addition, this evaluation shall verify whether validated and improved data is effectively and correctly used by service providers. This requires the inclusion of a downstream validation step, assessing data uptake and representation in navigation services (e.g. via tools such as RouteRadar, see section 7.6.1).

The evaluation shall cover five dimensions:

1. Validation Maturity
2. KPI & 5-Star Impact
3. Use and Value of External Sources
4. Service Provider Uptake Validation
5. Workload & Technical Sustainability

All PDV's shall use the same evaluation matrix to ensure comparability.

## 11.1 Validation Maturity

This dimension evaluates whether validation is systematic, scalable and robust.

Each PDV shall report:

- Which validation methods (V1–V11, see section 7.7) are operational
- Degree of automation (manual / semi-automated / automated)
- Average correction time after detection
- Existence of structured discrepancy logging (yes/no)
- Existence of defined decision logic (confidence, thresholds) (yes/no)

## 11.2 KPI & 5-Star Impact

This dimension evaluates measurable quality improvement.

Each PDV shall report:

- Baseline KPI values as described in the 5-Star Rating based validation method (Annex B)
- KPI values after one year
- Delta per KPI
- Baseline RTTI 5-Star Rating
- End RTTI 5-Star Rating
- 5-Star delta

An example of the KPI reporting and evaluation can be found in PDV Plan.

## 11.3 Use and Value of External Sources

This dimension evaluates how external data contributes to quality.

Each PDV shall report:

- Ground truth source(s) used
- FCD used (yes/no)
- SP feedback used (yes/no)
- RUF used (yes/no)

For each external source used, the PDV shall assess:

- Contribution to detecting missing events (low / medium / high)
- Contribution to reducing latency (low / medium / high)
- Contribution to improving accuracy (low / medium / high)

If possible, the PDV should quantify:

- % of corrections triggered by FCD
- % of corrections triggered by SP feedback
- % confirmed valid RUF cases

## 11.4 Service Provider Uptake Validation

This dimension evaluates whether validated and improved data is correctly used by navigation service providers.

Each PDV shall report:

- Whether a structured SP-uptake validation mechanism is implemented (yes/no)
- Tool used (e.g. RouteRadar or equivalent)
- Frequency of SP-uptake validation checks
- % of validated events correctly reflected in navigation services
- Average delay between publication and visible uptake in SP systems
- Number of discrepancies detected between published data and SP representation
- Number of corrections triggered towards SP's

If applicable, the PDV shall describe:

- Main causes of discrepancies (format, latency, interpretation issues, etc.)
- Escalation mechanism towards service providers

## 11.5 Workload & Technical Sustainability

This dimension evaluates operational feasibility and scalability.

Each PDV shall report:

- Estimated monthly workload for validation (person-days)
- Change in workload compared to baseline (increase / stable / decrease)
- Level of automation (low / medium / high)
- Major technical challenges encountered
- Main bottlenecks in the E2E process

## 11.6 Proposal Evaluation Matrix

| Dimension | Indicator | Baseline | After 1 Year | Comment |
|---|---|---|---|---|
| **Validation** | Validation methods operational (#) | | | |
| | Automation level (M/S/A) | | | |
| | Avg. correction time | | | |
| | Decision logic defined (Y/N) | | | |
| **KPI Impact** | Correctness rate (%) | | | |
| | Missing event rate (%) | | | |
| | False positive rate (%) | | | |
| | Avg. publication delay | | | |
| | Timing accuracy (%) | | | |
| | Geometry accuracy (%) | | | |

| | | | | |
|---|---|---|---|---|
| | RTTI 5-Star Rating | | | |
| **External Sources** | FCD used (Y/N) | | | |
| | SP feedback used (Y/N) | | | |
| | RUF used (Y/N) | | | |
| | % corrections from external sources | | | |
| **SP Uptake Validation** | SP validation mechanism in place (Y/N) | | | |
| | Tool used (e.g. RouteRadar) | | | |
| | % correctly reflected events | | | |
| | Avg. SP uptake delay | | | |
| | Discrepancies detected (#) | | | |
| **Workload & Sustainability** | Monthly workload (person-days) | | | |
| | Automation level (L/M/H) | | | |
| | Major bottlenecks identified | | | |

*Table 11: Proposal overall evaluation Matrix*

Each PDV shall provide on top a short summary (max. 1 page) describing

- Main improvements achieved
- Real added value of FCD / SP feedback
- Added value of SP uptake validation (e.g. RouteRadar insights)
- Key technical lessons learned
- Remaining structural weaknesses

All this information should be populated in the PDV Project Plan and will be input for D3.5 & D3.6

# 12 Conclusions and Next Steps

## 12.1 Conclusions

This deliverable establishes a comprehensive and harmonized methodological framework for validation and data quality improvement of road works, road closures and lane closures across all PDVs. It confirms that the maturity level of end-to-end (E2E) data processes across PDVs is heterogeneous.

A key conclusion is that most PDVs currently rely heavily on **manual processes and fragmented validation approaches**, resulting in variability in data quality, particularly in terms of completeness, timeliness, and consistency. While some advanced ecosystems demonstrate strong multi-source validation and operational integration, others are still in early stages of digitalization.

The introduction of a **common Quality Assurance (QA) framework**, combining validation, KPI calculation and continuous improvement, represents a critical step towards harmonization. The use of a shared reference methodology (with the TISA RTTI 5-Star Rating chosen as working example) provides a practical and scalable basis for benchmarking and improving data quality across all pilots.

Another key insight is the importance of **multi-source validation**, particularly through the integration of Floating Car Data (FCD), Road User Feedback (RUF), and service provider feedback. These sources significantly enhance the ability to detect missing events, reduce latency, and improve overall data reliability. However, their integration is not yet systematically implemented across all PDVs.

Furthermore, the analysis highlights that **data quality alone is not sufficient**: effective uptake by service providers remains a challenge. Limited feedback loops and lack of visibility on how data is used in navigation services reduce the overall impact of improved datasets.

Finally, the deliverable confirms that **automation is essential** for scalability. While manual validation remains necessary for complex cases, the transition towards automated validation, KPI monitoring and feedback processing is crucial to ensure sustainable operations and continuous improvement.

## 12.2 Next Steps

Building on this framework, the next phase of the project will focus on **implementation, operationalization and scaling** of the proposed methodologies.

First, each PDV shall develop and execute its **PDV Project Plan**, translating the common framework into concrete, context-specific actions. These plans will define selected validation methods, KPI targets, tooling requirements, and timelines for implementation.

Second, the project will progress through the **three-phase validation approach**:

1. completion of historical data collection,
2. execution of manual validation using the 5-Star methodology,
3. and transition towards **automated validation tools**.
   The development and deployment of these tools will be a key milestone to enable consistent, scalable and traceable validation across all PDVs.

Third, PDVs will prioritize the **integration of external data sources**, notably FCD, RUF and service provider feedback, into their validation and quality improvement workflows. This includes both technical integration and organizational processes to ensure structured and auditable use of feedback.

Fourth, efforts will focus on establishing **closed feedback loops with service providers**, enabling validation not only of data quality but also of data usage in downstream navigation services. This step is essential to ensure that improvements in data quality translate into real-world impact.

Fifth, PDVs will progressively **increase the level of automation** in validation and quality improvement processes, reducing reliance on manual intervention, and improving operational efficiency.

Finally, continuous monitoring and evaluation will be ensured through **KPI tracking and maturity assessments**, providing measurable evidence of improvement and supporting alignment with project objectives. The results of these activities will feed into the subsequent deliverables (D3.5 and D3.6), consolidating lessons learned and demonstrating impact at European scale.

# 13 Annex A – Key observations from the PDV's

This annex provides a high-level overview per PDV, summarizing the current status, identified gaps, planned actions, and recommendations. This includes recommendations on tools and methods that may be relevant for other countries, as well as input for other work packages. Where road works, road closures, and lane closures are managed in a similar manner, they are addressed jointly within a single paragraph.

The planned actions focus on strengthening both the validation process and the overall dataset quality improvement process. In particular, they describe the structured integration of Floating Car Data (FCD), Road User Feedback (RUF), and other third-party data sources into future workflows and tools. These enhancements are intended to improve the detection of discrepancies, increase accuracy and timeliness, support more robust KPI measurement, and enable continuous quality monitoring and quality improvement of road works, road closure, and lane closure datasets.

## 13.1 Belgium – Flanders - Key Observations

### 13.1.1 Belgium – Flanders – Road works

***High Level Description of current E2E process & tools used***

The current E2E process for RW under AWV own management ('gewestwegen') can be described as follows: In a planning phase, road works info is put into an AWV-own tool 'WERF' by own employees or contractors. This 'WERF'-tool is being used for planning, coordination, handling permits for signage, … During further evolution of planning, road works info is updated accordingly. Once a road work has been updated to the status 'final planning', the info is being extracted to another internal tool called 'Planned Events'. The road works info in this module is being screened by a Traffic Centre employee 'Scenario planner Traffic Management'. From this stage, there are two workflows, depending on the location of the road works (motorways vs non-motorways). For the non-motorways, the Scenario Planner does a rough validation (accept or reject). Only the accepted road works are kept in place in 'Planned Events'. For the motorways, the Scenario Planner also does a validation (accept or reject) and puts additional info for the Traffic Operators in an internal tool 'operational agenda'. All short term road works (mobile road works) are rejected in 'Planned Events, but are added to 'Operational Agenda'. The traffic Centre has an operational system 'VBS' which contains all real time traffic info (accidents, queues, road works, …) in Flanders. VBS pulls info from Planned Events, including road works. Road works on non-motorways are activated and deactivated in VBS at the scheduled dates and times automatically. All motorway road works in VBS are presented to the traffic operator at the date and time scheduled. According to other info (e.g. CCTV footage), the traffic operator activates/deactivates road works manually. Short term road works (mobile road works) are put into VBS at the time that they are reported by phone from the contractor who is actually on the road.

Every minute, the is a 'picture' taken containing all live traffic info in VBS and transformed into a DATEX2 feed, which is available on the Belgian NAP. This Datex-II feed contains all active road works at that moment (no planned road works). The traffic info in the'picture' taken every minute is also stored in our Data Warehouse (historical storage).

### *Current Navigation Service Performance*

All above-described road works info is available on the Belgian NAP in Datex-II V3 format. This is open data, we have no tracking on who is consuming what. So it is unclear at this moment how SP's obtain their RW info. Generally, RW info is better on the higher roads (motorways, primary roads, ...).

### *Source Data Quality & Coverage*

Source is AWV own system 'WERF' for RW planning (only road works under own management and on roads under our own management ('gewestwegen'). This does not contain all road works on AWV roads, but at least the major ones in terms of impact on traffic. Datex-II version 3. On motorways, this contains all road works, since this network is actively monitored 24/7. Quality on motorways therefore should be quite high.

### *E2E Process Effectiveness*

There is a working data flow from source to publication in place. It is supported by several tools. However, it still relies largely on human input from several different people in the chain.

### *Structural Gaps & Bottlenecks*

The road works info is only live road works, no info on planned (scheduled) events

### *Key Risks & Dependencies*

Quality is dependent on employees' input and their awareness of the importance of data quality.

### *Priority Improvement Areas*

Adding other data sources like data from SP's

Stronger integration of tools containing digital information (WERF) and obtaining permits and authorizations to increase the incentive for higher-quality input, integration and linking of track & trace impact absorber vehicles.

#### *Best practices*

In Belgium, all short term (mobile) road works must be marked by trucks equipped with impact absorbers. These vehicles therefore mark the location of the lane closure. By equipping these vehicles with track & trace, their location can be monitored in real time by the traffic centre. By linking this location data to the other road works information that is available in the traffic centre and then including this linked information in our Datex-II feed, the quality of mobile road works information increases significantly.

Via the Waze for cities programme, we have live access to crowd sourced traffic events from the Waze community. These events are presented as an 'incident detection source' to the traffic operators in the traffic control room. These events are merged with other detection sources like police notices, camera footage, … to traffic information that is send out in our Datex-Ii feed.

### 13.1.2 Belgium – Flanders – Road closures – Lane closures

#### *High Level Description of current E2E process & tools used*

The current E2E process for planned RC and LC under AWV own management ('gewestwegen') is part of the E2E process for RW as described above. On top of that, there is also information on unplanned RC and LC (due to incidents) on motorways.

The traffic Centre has an operational system 'VBS' which contains all real time traffic info (accidents, queues, road works, …) on Flanders' motorways. According to other info (e.g. CCTV footage, Police information, Waze, …), the traffic operator creates events, like accidents, adding the affected lanes which then are to be considered 'closed'.

Every minute, the is a 'picture' taken containing all live traffic info in VBS and transformed into a DATEX2 feed, which is available on the Belgian NAP. This Datex-II feed contains all active incidents whith the affected lanes. The traffic info in the'picture' taken every minute is also stored in our Data Warehouse (historical storage).

On top of that, in zones where there are gantries with dynamic lane control signs, the operator closes lanes by showing a red cross above the closed lanes. The real time info on the actual signing of the lane control signs is also available as an Open data feed, but this is not in a Datex-II format. However, we are working on integration of this feed into our Datex-II feed (planned to be operational Q3 2026)

### *Current Navigation Service Performance*

All above-described info is available on the Belgian NAP in Datex-II V3 format. This is open data, we have no tracking on who is consuming what. So it is unclear at this moment how SP's obtain their RW info. Generally, RW info is better on the higher roads (motorways, primary roads, …).

### *Source Data Quality & Coverage*

Source is live traffic information available in the traffic centre and obtained by combining multiple sources like road sensors, CCTV, police info, Waze, … In zones where we have live video, the information quality is high, in zones with no video, accuracy could be lower.

### *E2E Process Effectiveness*

This is part of the core business of our traffic center.

### *Structural Gaps & Bottlenecks*

Detection of incidents could be fastened by integrating and combining multiple sources.

### *Key Risks & Dependencies*

Lack on detection sources in certain areas at certain times.

### *Priority Improvement Areas*

Adding other data sources like data from SP's, SRTI-data from DfRS

Introducing AI for combining different detections and smart filtering

### *Best practices*

In Belgium, all short term (mobile) road works must be marked by trucks equipped with impact absorbers. These vehicles therefore mark the location of the lane closure. By equipping these vehicles with track & trace, their location can be monitored in real time by the traffic centre. By linking this location data to the other road works information that is available in the traffic centre and then including this linked information in our Datex-II feed, the quality of mobile road works information increases significantly.

## 13.2 Belgium- Antwerp - Key observation

### 13.2.1 Belgium – Antwerp – Road Works, Road Closures

Lane Closures are not implemented yet.

***High Level Description of current E2E process & tools used***

The City of Antwerp maintains two parallel data streams for generating road works and closure information used in its Slim Naar Antwerpen (SNA) route planner. One stream via GIPOD and the Shortcut tool and one stream via manually drawing in TREM. Currently only the stream via TREM is used.

The **TREM** stream centralizes all information from signage permits, impact-management meetings and internal databases, after which a staff member manually draws the work zone in TREM, with the necessary metadata, and the result is fed directly into the SNA planner provided by Be-Mobile. This workflow ensures precise, planner-ready information but also causes duplicated quality control across departments. Currently there is no DATEX-II export provided from Be-Mobile.

The alternative **Shortcut** stream originates with contractors entering work zones in A-Sign for signage-permit applications. Once a permit is issued, the work is recorded in VIOD and appears in GIPOD as polygons with metadata. Shortcut can convert these polygons into OSM-based road closures, and Shortcut can then export these work zones to DATEX-II format based on OpenLR localisation from OSM, which enables broad compatibility with navigation services. However, the automatic conversion of polygons to road segments requires manual control and the city notes that the metadata in GIPOD are not always up-to-date or give, for example, a validity window much larger than the actual period of disruption. Antwerp further observes structural inconsistencies — GIPOD contains much information that is not useful for route planners and information that is insufficiently qualitative — and commits through the Minder-Hinder/MCB programme to improving work-zone data quality at the source.

Neither Antwerp's TREM workflow nor the Shortcut workflow includes Floating Car Data (FCD) at this stage. A fully automated GIPOD → DATEX-II pipeline would require extensive filtering because the data in GIPOD undergoes insufficient quality control, making automated probe-data-driven correction unfeasible today. As a result, Antwerp relies primarily on human-curated validation, contractor updates, and community-driven feedback loops to maintain accuracy. TREM offers high precision through manual encoding, while Shortcut could provide scalable DATEX-II outputs but depends heavily on the quality and consistency of GIPOD input. The overall reliability of navigation services therefore hinges on Antwerp's combined efforts in data selection, manual review, and improving upstream metadata consistency — ensuring that published closures more closely reflect real-world conditions.

Current Service Performance

*Only the city's own service, "Slim Naar Antwerpen" currently has access to the data.*

*https://www.slimnaarantwerpen.be/en/route-planner*

### *Source Data Quality & Coverage*

*Currently the process is triggered by road-work permits being issued and all data are manually verified with the road works planning team. Internal data format still needs to be converted to Datex 2*

### *E2E Process Effectiveness*

*The current flow is robust, except where it depends on highly experienced and knowledgable employees to manually convert the data to a usable format.*

### *Structural Gaps & Bottlenecks*

The conversion from the internal data format to a public Datex II.

If better validation and data-conversion tools were available, the process could be more automated which could result in more road works being published in a qualitative manner using less personnel-time. One problem is that the data-sources are polygon/area based and need to be converted to network based for the service providers. This currently requires manual interpretation and network segment selection, especially when the area includes bridges or tunnels, or to distinguish between bike path, sidewalk and road.

### *Key Risks & Dependencies*

Quality is dependent on employees' input and their awareness of the importance of data quality. Limited number of employees currently have the necessary knowledge and skills.

Current process is not scaleable to the region because smaller cities do not have sufficient personnel to make this process reliable.

### *Priority Improvement Areas*

1) *Publish Datex-II*
2) *Collect feedback*
3) *Set-up process to evaluate feedback and incorporate feedback into data.*
4) *Implement a Large Language Model to scrape internal documents (e.g. meeting minutes at all levels) for information about changes to RW/RC to trigger QC action.*

*This may also be used to organize feedback from road users if volume is too high for manual processing.*

***Recommended Actions***

a. *Publish Datex-II*
b. *Collect feedback*
c. *Set-up process to evaluate and incorporate feedback into data.*

***Best practices***

*Start with a small quality data stream that is network-based.*

## 13.3 Croatia - Key observation

### 13.3.1 Croatia – Road Closure – Lane Closure

***High Level Description of current E2E process & tools used***

The Croatian end-to-end (E2E) process for road closures (RC) and lane closures (LC) is based on the operational activities of Hrvatske ceste d.o.o., supported by a network of Regional Traffic Management Centres (RCNUP) and a Central Traffic Control and Management Center (SCNUP-DC), which are part of the Croatian Roads system and responsible for real-time traffic monitoring and incident management across the state road network.

Data on road closures and lane closures is collected through a unified internal RAMS subsystem of Hrvatske ceste, where both maintenance companies and RCNUP operators input and manage data. This includes information on both planned closures (related to scheduled works) and unplanned closures or lane restrictions (resulting from incidents, accidents or emergency situations). The use of a single system ensures consistency of data and enables continuous updates, as RCNUP operators can validate, modify or activate closure events in real time based on actual traffic conditions and operational insights.

The Regional Traffic Management Centres (RCNUP) are responsible for operational monitoring and first-level validation of traffic events in their respective regions, while the Central Traffic Control and Management Centre (SCNUP-DC) performs centralized supervision, second-level validation and final approval of data before publication. This hierarchical structure ensures both local responsiveness and national-level consistency in traffic data management.

Within this process, operators in the SCNUP-DC review incoming data, perform additional verification and cross-check inputs originating from maintenance companies and RCNUP centres against available traffic monitoring sources (such as CCTV systems, traffic sensors and, where applicable, Floating Car Data provided by VIATEL), and update the status of events in real time. Only validated and confirmed information is then published to end users via the Croatian National Access Point (NAP) (www.promet-info.hr), in Datex II v3 format.

This centralized validation approach ensures a high level of data governance, operational control and consistency across the national road network, while supporting the delivery of reliable and timely traffic information to service providers and end users.

### *Current Service Performance*

Currently, the integration of external data sources such as Floating Car Data and user feedback into the validation and enrichment process is partially implemented. Ongoing activities, including pilot use cases within TISGRADE, are focused on increasing the level of automation, improving detection of real-time events and enhancing the overall accuracy and timeliness of RC/LC data.

Navigation services partially reflect roadclosure / lane closure data, with better performance on major roads.

### *Source Data Quality & Coverage*

The main source of roadworks, road closure and lane closure data in Croatia is the internal subsystem of Hrvatske ceste d.o.o., where maintenance companies input data on planned and ongoing works. Additional input is provided by Regional Traffic Management Centres (RCNUP) and the Central Traffic Control and Management Centre (SCNUP-DC) through real-time monitoring and validation using CCTV and sensors. Floating Car Data (FCD), provided by VIATEL, is being progressively integrated to support validation.

### *E2E Process Effectiveness*

Data is published via the Croatian National Access Point (NAP) in Datex II v3 format (XML, HTTP/HTTPS). Coverage is moderate to high for the state road network, with good completeness for planned events. Accuracy is high for major events due to centralized validation, while timeliness is near real-time, with some dependence on manual processes.

The E2E process from data source to consumption is operational and robust, based on a multi-layer validation approach involving RCNUP and SCNUP-DC. Data is collected through the Hrvatske ceste subsystem, centrally validated and published via the NAP in Datex II v3 format. The process enables near real-time data flow and ensures consistent and reliable information delivery. However, it remains partially dependent on manual validation, with ongoing improvements focused on automation and integration of external data sources such as FCD.

### *Structural Gaps & Bottlenecks*

The current process includes several manual interventions, particularly in validation and data updates, which may lead to delays in real-time accuracy. There is no fully implemented automated validation or enrichment process, and integration of external data sources such as FCD is still partial. Feedback mechanisms from service providers and end users are limited, resulting in insufficient data quality monitoring and improvement loops. Additionally, while data is standardized in Datex II v3 for publication, upstream processes and tools are not yet fully harmonized or automated

### *Key Risks & Dependencies*

The main risks are related to dependency on external data providers, particularly for Floating Car Data (FCD), including data availability, quality and continuity of service. Additional risks arise from limited integration of user feedback and the current lack of fully developed mechanisms to systematically process and validate such inputs. Technical limitations and partial system interoperability may affect the efficient integration of multiple data sources into the validation workflow. Furthermore, regulatory and organizational dependencies between stakeholders may impact data sharing, coordination and timely updates.

### *Priority Improvement Areas*

Priority improvement areas focus on increasing the level of automation within the E2E process, particularly in data validation and real-time updates. A key direction is the integration of Floating Car Data (FCD), crowdsourcing data, and user feedback into operational workflows to support automated validation and data enrichment. Further improvements include the development of tools for processing and analyzing multiple data sources, as well as the establishment of structured feedback mechanisms with service providers. These actions aim to enhance data accuracy, timeliness and overall reliability of the datasets.

### *Recommended Actions*

Recommended actions focus on implementing automated validation mechanisms supported by Floating Car Data (FCD), crowdsourcing data and traffic monitoring systems. It is necessary to develop and deploy tools for processing, analyzing and integrating multiple data sources, including user feedback, into the validation and enrichment workflows. In parallel, structured feedback loops with service providers and end users should be established to enable continuous data quality improvement. These actions should be supported by strengthening interoperability, improving system integration and gradually reducing reliance on manual processes.

Proposed data flow is presented in picture:

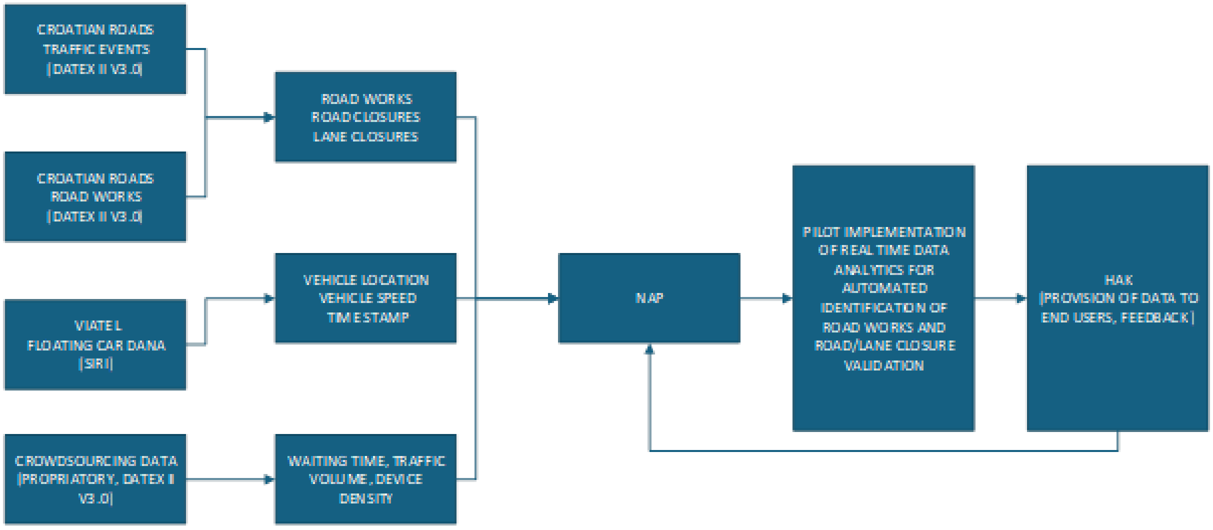



*Figure 11: Proposed dataflow Croatia*

## 13.4 Cyprus - Key Observations

### 13.4.1 Cyprus – Road works

***High Level Description of current E2E process & tools used***

Following the recent renewal of internal systems and operational procedures within the Road Authority (Public Works Department – PWD), including the transition to the new Traffic Control Room in Cyprus, temporary adjustments have been introduced to the road works registration and monitoring process. During this transitional phase, the road works permit application process (including contractor agreements, police approval, and related validation and monitoring activities) is being managed through an analogue (paper-based) procedure. The relevant information is subsequently published on the PWD website (for the road network under PWD authority) under the Road works and Press and Information Office (PIO) update sections. Regarding roads under municipal authority, they also publish updates on road works in the relevant sections of their websites.

The **diagram below presents the target (planned)** end-to-end (E2E) workflow. The answers to the following questions are provided with reference to the current E2E situation and/or the planned E2E configuration.

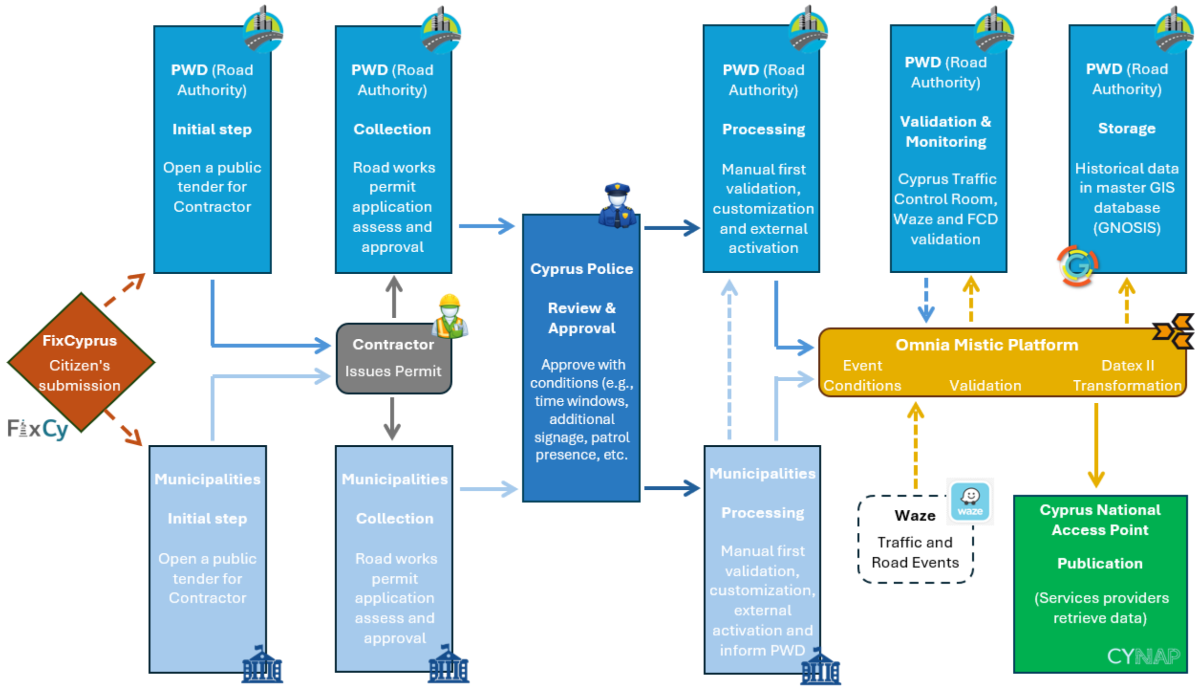



*Figure 12: The target (planned) end-to-end (E2E) workflow for Cyprus*

### *Current Service Performance*

At present, the road works information made available through the Cyprus National Access Point (CyNAP) is derived from procured Waze (events) data, following a validation process carried out by the Road Authority. No service provider retrieves road works data from CyNAP, as the corresponding ground truth data is currently not made available digitally.

The road authority uses the OMNIA MISCA platform from SWARCO to edit, validate and export (in DATEX II) RW/LC events, and then publishes these on the CyNAP.

### *Source / Information / Data Quality & Coverage*

No ground truth road works data is currently being provided.

### *E2E Process Effectiveness*

As the current E2E workflow remains in analogue (paper-based), a comprehensive assessment of the procedure's effectiveness cannot be conducted at this stage. Upon transition to a fully digital process, including integration with the Cyprus Omnia Mistic platform, the overall robustness and reliability of the workflow are expected to be positively enhanced.

### *Structural Gaps & Bottlenecks*

As a result of the recent renewal of internal systems and operational procedures within the Road Authority, the planned digital workflow has not yet been re-established. Furthermore, several key steps remain unimplemented, including the integration of the unified Omnia Mistic platform, the systematic publication of data through the CyNAP, and the associated storage mechanisms.

### *Key Risks & Dependencies*

Regarding the planned E2E configuration, potential risks have been identified, particularly concerning stakeholder engagement (including municipalities, police, and the Road Authority) and dependencies linked to the unified platform operated by a third-party provider.

### *Priority Improvement Areas – Wish scenario*

- Digitalisation of the Road Works Process - Transition the entire road works registration and monitoring process from a physical (paper-based) system to a fully digital workflow – Digital process planned to start in the Q2 2026.
- Enhancement of Data Validation Procedures - Strengthen and formalise the data validation process within the Traffic Control Room to ensure higher data accuracy, consistency, and reliability.
- Data Publication via CyNAP - Ensure the systematic availability and publication of validated ground truth road works data through the CyNAP.

### *Recommended Actions*

- The Road Authority (PWD) should provide structured training to all stakeholders involved in the unified road works platform, ensuring proper understanding of roles, responsibilities, and system functionalities.
- Ensure that the unified platform fully supports all operational and regulatory requirements (e.g. applicable standards, data models, validation rules, and interoperability needs) to enable an efficient process.
- The Road Authority (PWD) should also deliver targeted training to Traffic Control Room operators, with a focus on strengthening data validation and monitoring capabilities to enhance overall data quality and reliability.

### *Best practices*

Although the system is not yet operational, we are already developing validation methodologies for road works data that will also be integrated into the planned E2E process:

- Use of Floating Car Data and road works hazard events (e.g. Waze alerts) to support cross-validation (with various ITS infrastructure) and monitoring of reported road works, enhancing situational awareness and data reliability.
- Integration of *FixCyprus*, a mobile application that enables citizens to report road infrastructure issues affecting road safety in Cyprus. In the future, this solution is possibly expected to also function as a structured feedback mechanism, allowing users/citizens to provide input relevant to road works validation and monitoring.

Recommendations towards WP4 - WP5

We strongly expect to receive best practices and reference architectures for NAP-driven feedback loops, enabling structured data quality monitoring, bidirectional communication with service providers, and continuous improvement within the overall E2E process.

## 13.5 Finland - Key Observations

### 13.5.1 Finland – Road works

***High Level Description of current E2E process & tools used***

FCD Data is not currently used for validation. Contractors have web- service and special telephone service number for this process. Traffic management Center manages the process and Traffic Management Centre (TMC) need to manually validate and confirm road works-info before a DATEX-message is created and provided to external stakeholders. In parallel, everything that are provided to external stakeholders, are stored in our database for historic traffic information.

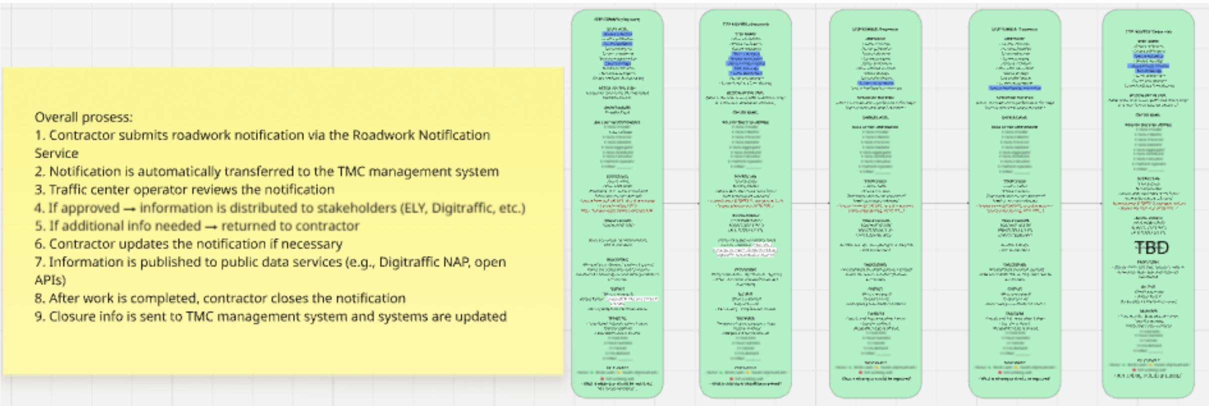



*Figure 13: E2E Flow Fnland*

***Current Service Performance***

Existing service providers: Google, Tomtom and Here are using our traffic announcement data and it is also available for DFRS community. Most municipality roads and streets lack information on road works. We have some ad-hoc follow-up on how Service Providers use our data, like from Waze impact report.

### *Source Data Quality & Coverage*

Source data quite often lack positional accuracy and timeliness even though the overall coverage and completeness for state roads is OK.

### *E2E Process Effectiveness*

We have a working data flow from source to publication, transformation between formats and publication work quite well, validation is not robust enough.

### *Structural Gaps & Bottlenecks*

Adapt the validation process with dynamic traffic model (FCD included) and automated feedback loop if possible and common Tisgrade way has been found.

### *Key Risks & Dependencies*

FCD data is not used in the process.

### *Priority Improvement Areas*

Adaption to use FCD and User Feedback for validation & Improvement. Better distribution of traffic over network, Improved routing in traffic disruption situations and temporary roadwork detours.

User Story

- As a data publisher, we want all “Road Closed” events to include an explicit impact direction in both directions, because currently this information is often missing in our source data. Without impact directions, partners like Waze cannot process the events on bidirectional roads.

Acceptance Criteria:

- “Road Closed” events must always contain an impact direction for both travel directions.
- If the original source data lacks this information, the system must generate or infer a default bidirectional impact direction.
- Events without impact direction must no longer be published as-is.

- Waze and other consumers accept the events without validation errors.

***Recommended Actions***

Automatic validation and correction of impact directions. Structured dialogue with and feedback from Service Providers.

## 13.6 France - Key Observations

### 13.6.1 France Road works

#### *13.6.1.1 High Level Description of current E2E process & tools used*

On National road network operated by the “Interdepartemental” road Directorate, named DIR, the French NAP published on occurrence the roadworks (Forecast and real). That is the case of DIR Mediterranee which is one of the pilot sites of TISGRADE. The standard used is Datex II version 2.3 according to the French Ministry policy. The next version of Datex II to update the huge deployment of TIPI will be version 4.

On the “Departmental” network, each Counsil of Departement decides the way it publishes its information. For the Departement of Hérault, it publishes on its own open data website with several format but not Datex II[4].

On the Metropole (which are one of the type of Community of Communes) and commune road network, each of them has its own policy to publish roadworks and accompanying measures. For the Metropole of Nice Côte d’Azur, the policy is responsibility of the Metropole Council. With the results of the last elections last month, changes could append.

For a lot of the 34,875 communes which are small, the way they publish traffic regulation orders is mainly official panel and local newspapers.

#### *13.6.1.2 Current Service Performance*

The navigation services are not reporting how they use the RTTI.

From 90’s to 2010, the French Ministry and service providers who was connected the electronic data publication of SRTI and RTTI had every 6 months one day meeting to exchange on errors and procedures, to find way to increase the quality of the end-to-end process.

With the working group to consider the ITS Directive 2010/40, this process has been suspended. It appears during this process that some big new appearing service providers which were not involved before have not taken part to the working group even if many invitations have been sent.

In parallel, the French Ministry has invested efforts and budgets to change the aging IT systems based on national standard and Datex into TIPI systems publishing in Datex II.

The NAP behind Bison Futé which exists on Internet since 1997 (previously it was a telematic offer over Minitel) is continuing to run but only with the coverage of the national road network. This change is due to the evolution of the French administrative organization. From 2007, Council of Departement are operating their network alone than before it was operating by French Ministry of infrastructures local agencies on the behalf of the Departement. With this new law, a large part of the national road network has been transferred to the Departement and declassified from national to local roads.

Due to this reorganisation, the process to adapt RTTI is very different from one to another Departement depending the priorities of local policies and also the importance of the traffic lows.

#### *13.6.1.3 E2E Process Effectiveness*

Each source has its own validation process. On the national road network, each roadwork is controlled by the patrol of the motorway operator or of the local DIR.

For other road network, the roadworks, which are not concerning the road maintenance or the changes in the road layout, are subject of uncertainty because the company which has requested the right to operate on (or more precisely under the pavement) do not report the exact beginning and end of the roadworks effectiveness. More the level of the road is low, less is the report done.

#### *13.6.1.4 Structural Gaps & Bottlenecks*

Some service providers which were not cooperating within the Working group from 2010 to 2012, have developed direct cooperation with local authorities. By developing a dedicated tool to provide the RTTI in a format which is proprietary to one service provider without respecting the publication in open data in shared standards, these local authorities commit an offense of favouritism.

That is one of the main gaps which can be identified. The second one is the adoption of the European standard Datex II.

#### *13.6.1.5 Key Risks & Dependencies*

The main limitation for authorities is the cost and the budget.

#### 13.6.1.6 Priority Improvement Areas

As the French Ministry IT system work and is on track to evolve to adopt Datex II version 4, the connection of local authorities to it could be a very good solution to help them with low investment.

This connection could be realised by integrating in the software used by the local authorities to write their traffic regulation orders of an export of it in Datex II format.

In parallel, the evolution of the national application CoopITS to be a tool for companies which are operating the roadworks to input in real time the beginning and the end of the roadworks in accordance with the regulation order.

#### 13.6.1.7 Recommended Actions

See the previous paragraph.

In addition, on April 7th 2026, Cerema organised a Technical Territorial Conference with some road operators of the Provence Region in Aix-en-Provence to exchange about road operation, road maintenance and to present the new regulation published last 24 March and the interesting cooperation that TISGRADE can offers for them.

#### 13.6.1.8 Best practices

See the example of the Departement des Hautes-Alpes in the best practice part of this document.

#### 13.6.1.9 Recommendations towards WP4 – WP5

For the WP4, if a service provider has developed a direct connection with a local authority and is the only one which received the RTTI then it must be mandatory that it transmit back this information on the NAP as it is subject on favouritism.

For WP5, defining rules to provides feed back of the data they are already have to the authorities in order to help them to become aware of the effort to do. In this case, local authorities have to guaranty the service provider to not disclose this information to their competitors.

### 13.6.2 France Road Closure – Lane Closure

This part will have the same contain that roadworks part has road closures, lane closures are part of the traffic management included in the roadworks traffic regulation orders.

The only change is the rerouting which for the national road network based on the signage of “delestage” itineraries as described in the best practices deliverables.

For Departement and Communes, rerouting are also part of the roadworks traffic regulation orders.

## 13.7 Italy – Port of La Spezia

### 13.7.1 Italy – Port of La Spezia - Road works

***High Level Description of current E2E process & tools used***

Road works information in the La Spezia Port Area is currently presented via Variable Message Signs (VMS). Interoperable digital datasets, structured publication towards a National Access Point (NAP) or external service providers are not implemented. Coverage is limited to users in the port domain. No structured real time update mechanism is available. The current maturity level corresponds to a locally operational communication. The La Spezia port road network represents a critical node connecting maritime flows with TEN-T corridors and hinterland logistics chains, where timely and interoperable traffic information plays a key role in ensuring efficiency, safety and network resilience.

***Current Service Performance***

Information about road works affecting the internal port road network is sourced via internal coordination meetings with contractors and stakeholders, and formalization happens through presidential orders issued as documents. Available attributes include planned timeframe and intervention location. Some structured attributes are not managed, as work type classification, indication of the impact on road capacity, precise georeferencing and quality metadata. Data standardization is not yet implemented.

***Source Data Quality & Coverage***

Information about road works affecting the internal port road network is sourced via internal coordination meetings with contractors and stakeholders, and formalization happens through presidential orders issued as documents. Available attributes include planned timeframe and intervention location. Some structured attributes are not managed, as work type classification, indication of the impact on road capacity, precise georeferencing and quality metadata. Data standardization is not yet implemented.

***E2E Process Effectiveness***

The current process is administratively driven rather than data-driven.

Current flow: information gathering, issuance of presidential order, dissemination to stakeholders via VMS.

A digital data model, pre-publication validation, ITS-compliant transformation, machine-to-machine APIs or data feeds are not available.

### *Structural Gaps & Bottlenecks*

Administrative orders are not integrated with a digital traffic information system, a structured dynamic dataset is not available. The process is manual and dependent on formal communications. The digital environment targeting port stakeholders and users (Port Community System - PCS) is not complemented with road traffic information.

### *Key Risks & Dependencies*

Dependence on administrative acts. Dependence on the future development of the PCS. Multi-actor coordination complexity (Port Authority, terminal operators, haulage companies). Risk of non-timely updates.

### *Priority Improvement Areas*

In the short-term, it is advisable to define mandatory closure fields and to progress on digitalization of the reporting process.

On a medium-term time frame, actions include to implement a traffic module to complement the PCS platform with a traffic control room; to start alignment with European ITS standards; and to manage temporal and spatial consistency checks.

### *Recommended Actions*

Short-term: define minimum data schema; formalize digital reporting; introduce completeness checks. Medium-term: integrate GIS and spatial model; implement PCS API; perform DATEX II mapping.

### *Best practices*

What do you recommend other countries

- The Port Authority involves operational stakeholders in the information provision and circulation phases.
- Well-established and working administrative workflows, to be evolved with digital data flows.
- Overlapping of planned works in principle should be avoided.

### 13.7.2 Italy – Port of la Spezia – Road Closure – Lane Closure

#### *Current Service Performance*

Closure information is disseminated to Port users but no structured publication towards NAP or navigation service providers is implemented. Coverage is limited to internal port users. The system maturity corresponds to a local informational system without interoperability.

#### *Source Data Quality & Coverage*

Organizational definitions: road closure = blocked road section; lane closure = blocked lane; minimum duration threshold = 30 minutes. Sources include internal sources, TOS (gate lane closures), and email/phone communication. No formalized data schema, standardized georeferencing, structured attributes (direction, severity, lane numbering), lifecycle model, or interoperable standards are implemented.

#### *E2E Process Effectiveness*

The typical flow comprises internal information collection, formalization through presidential order, dissemination via email/phone in case of delays. Structured multi-source aggregation, real time validation, standards transformation, APIs are not implemented. Validation occurs with personnel supervision while the event is active and afterwards.

#### *Structural Gaps & Bottlenecks*

No machine-readable dynamic dataset. Dependence on manual communication channels.

#### *Key Risks & Dependencies*

Dependence on email/phone communication. Dependence on PCS evolution. Multi-actor coordination complexity

#### *Priority Improvement Areas*

Implementation of a digital closure/lane closure dataset. PCS integration with a road traffic management module to ensure systematic data handling. Establishment of interoperable data flows to enable external publication, with the long-term objective of facilitating potential integration with the National Access Point (NAP)..

#### *Recommended Actions*

In the short-term, it is advisable to define mandatory closure fields and to progress on digitalization of the reporting process.

On a medium-term time frame, actions include to implement a traffic module to complement the PCS platform with a traffic control room; to start alignment with European ITS standards; and to manage temporal and spatial consistency checks.

***Best practices***

Consolidated E2E flow, as a starting point for digitalization prior to publication.

Operational systems (PCS, TOS) information can be integrated with traffic information systems. Establish a shared minimum dataset across port road users typologies.

Define clear governance between Port Authority and operational stakeholders.

## 13.8 Netherlands (Amsterdam/Helmond/NDW) – Key observations

In this paragraph, the key observations for Amsterdam and Helmond (including NDW as part of the ecosystem in the Netherlands) are described, as well as the improvements we want to achieve in the PDVs.

If there is a difference between Amsterdam and Helmond, this will be explicitly mentioned.

We start with some **overall** remarks. Then the specifics for road works and events are described. And after that, the specifics for road closures are described.

### 13.8.1 Overall (road works and road and lane closures)

Key principles in the PDVs in the Netherlands are:

- The PDV locations in the Netherlands are Helmond and Amsterdam. NDW plays an important role in these PDVs as part of the ecosystem.
- Execution of the PDVs is carried out in close cooperation with the Dutch programs called ARAMIS and ´Pioneers Approach‘ program.

- In accordance with the TISGRADE T3.2 & 3.3 Project Plan, we distinguish the following types of validation:

    a. Preventive validation (automatic rule checks, intake checks)
    b. Operational monitoring (active status checks, spatial and temporal validation)
    c. Structural analysis (KPI monitoring, root cause analysis, process optimization)
- For structural analysis, we use level 3 of the TISA 5-star rating specification for the objectively determinable criteria.
- For those criteria that require “ground truth”, we will rely on operational monitoring and merging of different data sources to determine the probability at data-item level and include it in the data feed.

- For structural analysis, a connection will be made with the dashboarding provided by the ARAMIS project for road works and road and lane closures.
- Determining the KPIs will initially be done manually at the start of the PDVs, but during the one-year PDV period this will transition to automated KPI determination (with the input of TISGRADE).
- To determine improvements during the PDV period, a baseline measurement will be carried out at the start.

### 13.8.2 Road works

***High Level Description of current E2E process & tools used***

First, the internal processes of Amsterdam and Helmond are described, followed by the description within NDW prior to publication on the Dutch NAP (NTM).

**AMSTERDAM:** Within Amsterdam, 3 types of road closures are defined:

1. Medium and high impact road works, leading to complete road closures.
2. Small local road closures, like moving trucks blocking the road.
3. Large scale events, like a Marathon event.

The following process steps are performed for each of these types:

1. **Programming phase**
   This phase concerns long-term, multi-year coordination of major road works within Amsterdam. The City of Amsterdam's application, Programming is registered in a separate planning tool ('Uitvoeringsprogramma')
2. **Regional coordination**
   This is a subsequent step in cases involving interregional dependencies. The *MELVIN* application is used to support this stage by adding planned closures in concept to the projects.
3. **District road management**
   This phase covers the approval of planned road works and traffic measures within Amsterdam. The City of Amsterdam's *Victor* application is used to support this process.
4. **Registration in MELVIN**
   Once the road works have been formally approved, the responsible Amsterdam official enters the road works into *MELVIN* with final status. Any subsequent changes to the planning must be updated in *MELVIN* accordingly.

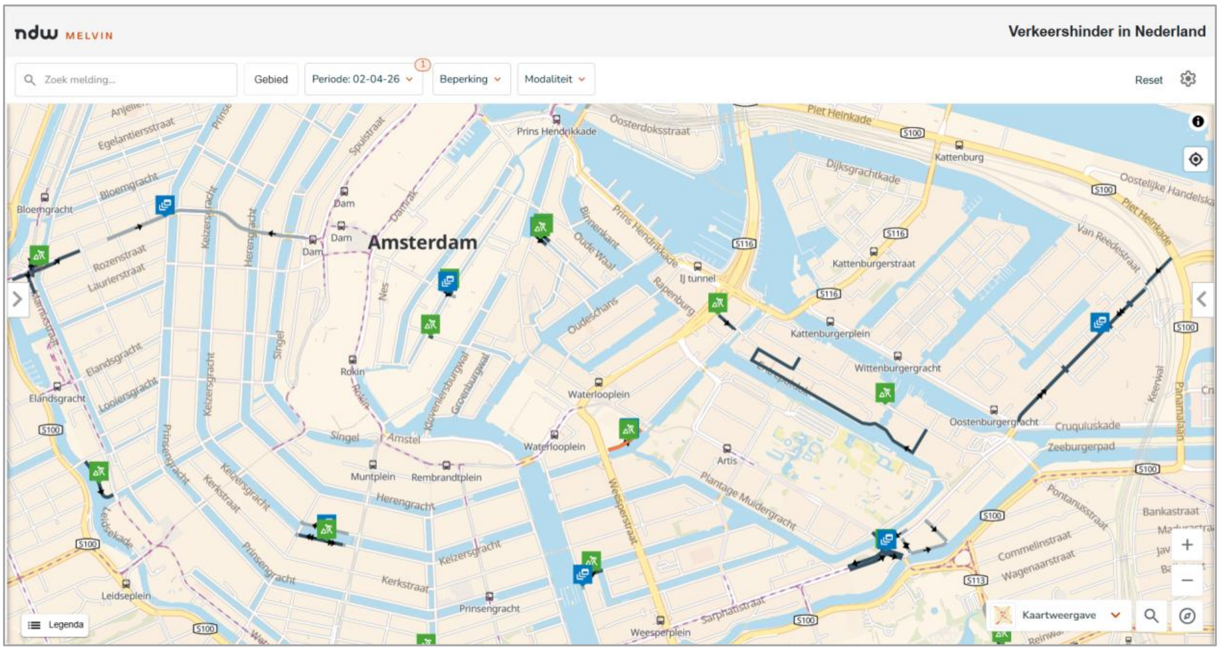



*Figure 14: Example of input interface for roadworks in MELVIN*

**HELMOND:** In Helmond the basic process is based on the following steps:

A. **The design** of the measurement that supports the road works. This can be relatively simple, like a warning and a speed limit, or complex with several phases (in time) and route deviations, closures etc. The design is laid down in an AutoCAD drawing (see below).
B. **The validation** of the design in terms of consistency, planning, effect on traffic flow/throughput, and coordination with other traffic measures in the same area or road network. The validation is always done by a Helmond official.
C. **The translation of the information to data**. For this, a system is used (in our case LTC Andes). The data in this system is exported to the backbone of the Dutch NAP (NDW). The traffic measure can be planned ahead in the future. In Helmond ca. 100-150 traffic measures are scheduled.
D. **Publication by the NAP** to the service providers, once the measure is active in the registered time slot. This is an automatic mechanism.
E. **Changes** occur from new planning insights or other reasons. In such a case the validation processes is again executed by the Helmond official and entered into LTC again.
F. **Ending the road works** traffic measure is done automatically, when the time passes the (digital) end-time. It can be done manually, but that's more exception than rule.
G. The **NAP retracts the publication** to the service providers.

The city does not use any feedback now from FCD or equivalent.

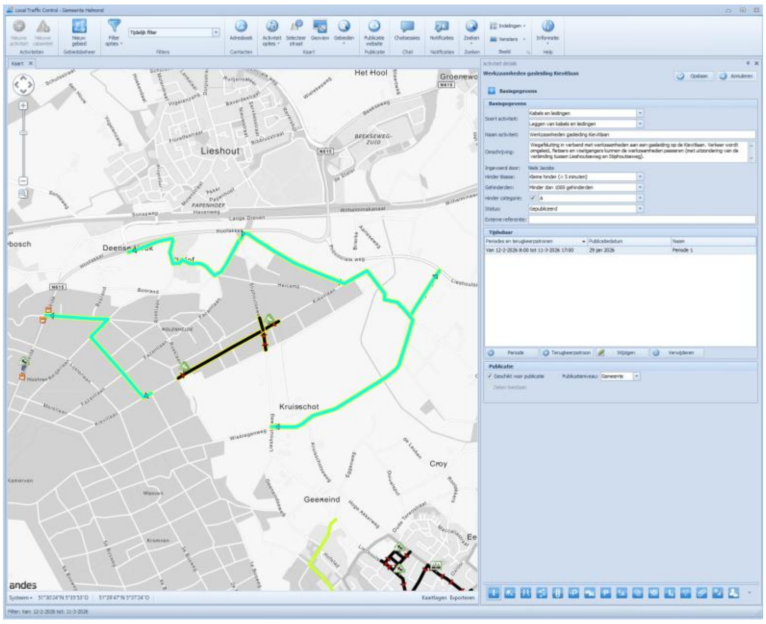


Figure 15: Example of input interface for roadworks in LTC Andes

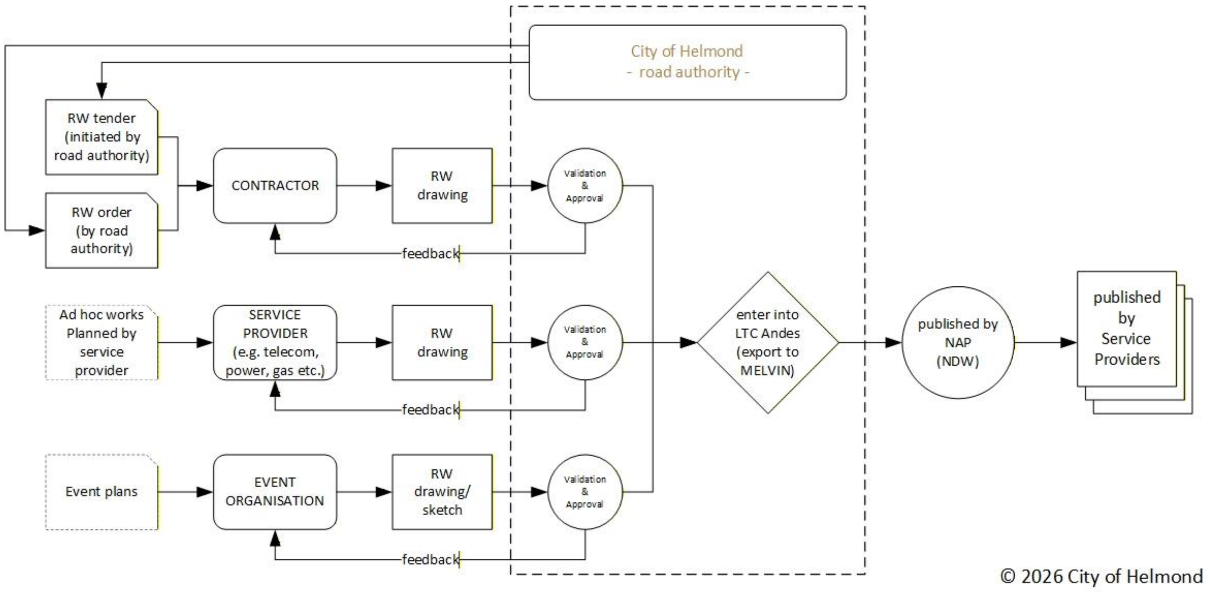



Figure 16: Process from road works plan to publication of the measures in Helmond

Road works in Helmond can be categorised in three categories:

(i) Works resulting from a **contracted project** e.g. from an infrastructure company. These works are known well in advance (months/years) and can and will be planned ahead. The programmed time slot is regularly updated as the execution of the project comes nearer. The contractor needs to provide a design of the road works measurements (with a seldom exception that sometimes Helmond does this itself).

(ii) **Ad hoc works** coming from service providers like cable companies, telecom companies or providers of e.g. drinking water, gas and electricity, building companies etc. Some of these works come unplanned (< 2 weeks), some are announced 2 weeks – 2 months in advance. The process of design and approval of the plan is equivalent to a contracted project, even if the road works are urgent and needed on very short time.

(iii) **Events** of all kinds of nature (sports, culture). These are planned on one or more days and normally known well in advance. Also here, Helmond asks the event organisation to provide a plan. Such a plan will probably be less professionally drawn as for the other works. Then Helmond will work it out in more detail.

The characteristics of the three categories are (roughly) as follows:

| | (i) Contracted | (i) Ad hoc | (ii) Event |
|---|---|---|---|
| Time | planned | urgent – planned | planned |
| Time negotiable | yes | sometimes | no |
| Feedback (in/out) | yes (courtesy) | yes | no |
| Specified by city | yes | no | yes |
| Phased | yes (sometimes) | no | no |

For all three categories the road authority (Helmond) will approve the measures to be taken. Also, Helmond may estimate the effects of the planned measures on traffic flow and throughput, depending on the complexity and the expected impact. This estimate is done on insight, experience and feeling. Seldom a calculation is being made (e.g. VISSIM simulation).

The road works plan can be made by Helmond exclusively or it must be proposed by the contractor, after which Helmond needs to approve the proposal. Of course, the road authority can make modifications to the proposed plan.

The measures are laid down in a drawing (see example below). The drawing forms the de-facto start data in the chain of information towards, in the end, the service provider.

Figure 17: Drawings roadworks plan

Conclusion is that in general, as far as the city of Helmond is concerned, the navigation services reflect the road works in a satisfactory way. However, especially timing (start-end moment) can sometimes deviate from reality (see below).

**NDW:** Within NDW, the basic process is based on the following steps:

1. **Input & Gathering**: Data is created and gathered via Contractors, TMC, Road Authorities and private data sources. Road authorities enter planning and execution data in MELVIN, or is imported from other systems (e.g. LTC, SPIN) into MELVIN.
2. **Rule base input check: t**he data in MELVIN ise checked with a set of business rules to gain insight in the quality of the input. This information is returned to the road authorities via a quality dashboard.
3. **Ground truth comparison: t**he data in the database are compared with Floating Car Data with the IDEA algorithm and thus provided with an estimation of probability that road works have started.
4. **Publication**: once released, data enters NDW's MELVIN product, which is standardize in DATEX II V3 format.
5. **Access & Delivery**: the data is delivered via NDW's open data portal.

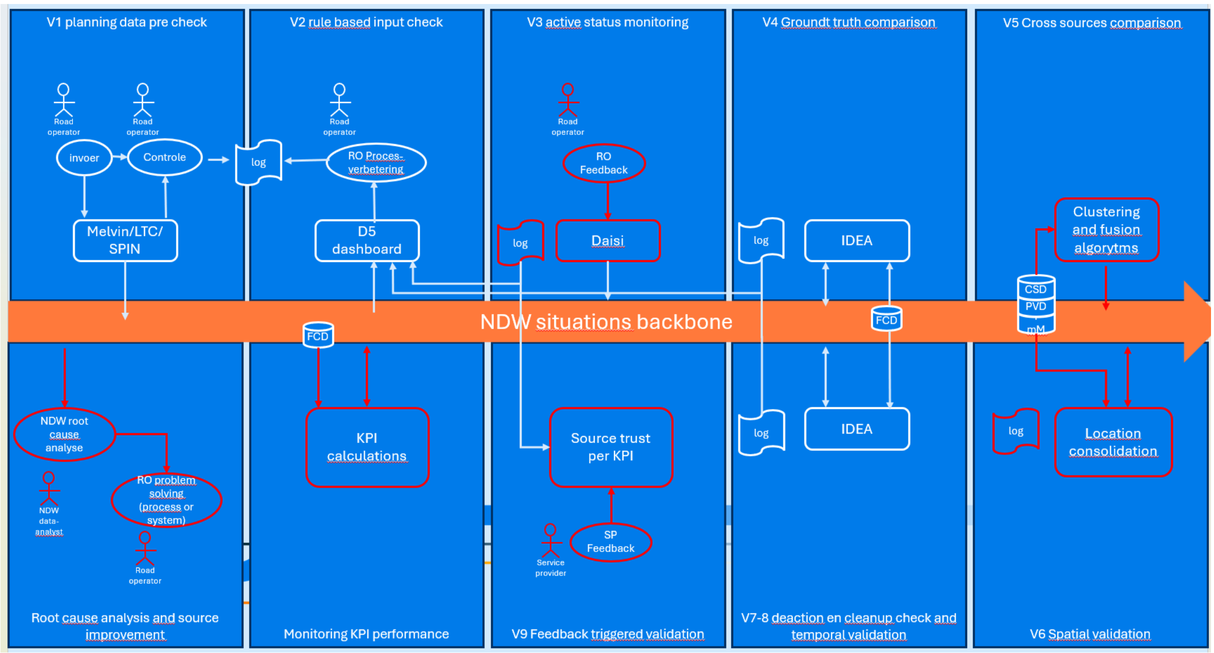



Figure 18: Architecture from road authority to road user

In the figure above the relation with paragraph 8,7 has been made. V1 is described in the road authority process in the above. V2 – V10 show several components for validation. When drawn in white they are in place or will be in place soon. When drawn in red they are considered for development in the next year in the ARAMIS program

Internal quality assurance is supported through relevant field checks and logic within MELVIN. For example, when creating or editing a road works notification in MELVIN, the system performs automatic pre-save checks. If required information is missing or inconsistent, MELVIN displays warnings that must be resolved before the notification can be saved. In addition, the DATEX II product schema includes validation elements defined in the standard profile XSDs, that clarify the expected structure of the data.

### *Current Service Performance*

**AMSTERDAM**: For all road works registered in MELVIN, service providers are able to retrieve the relevant data via the NDW through the National Access Point (NTM).

In Amsterdam, the roadworks process has recently been strengthened. Data entry into MELVIN is now carried out by the local district coordinator, a municipal employee of the City of Amsterdam. This organisational adjustment is expected to contribute to improved data consistency and reliability.

At present, the quality of the MELVIN data provided by Amsterdam is considered to be of a high standard. However, independent validation, the TISA 5-star rating by TISgrade is requested to formally substantiate this assessment.

**HELMOND:**

#### Completeness

The completeness of the traffic measure is at a high level. This applies to the following aspects:

- The affected road segment(s).
- Direction of the (eventual) closure.
- The modality involved: e.g. pedestrians, bicycles, all traffic etc.
- Redirection indications per modality and per destination.
- Follow-up signs in case of a redirection.
- Road works warnings including speed limitations (e.g. 30 km/h).
- Eventual phases (in time) of the measures.

**Estimated RTTI-5-rating : L5**

#### Accuracy

For the planned road works the location accuracy is very high for all objects (segments, signs): ≤ 50 m.

Estimated RTTI-5-rating : L5

For Ad hoc measures this may lie at a lower level: ≤ 50 m.

Estimated RTTI-5-rating : L5

Since most of the measures are planned RW and events, the estimated rating is at least L5: ≤ 50 m.

Estimated RTTI-5-rating : L5

### Timeliness

This may differ for planned RW, ad hoc activities and event. The estimate levels are listed in the below table.

| Uncertainty in time | Start | End | RTTI-5* |
|---|---|---|---|
| Planned | < 2 hrs | < 3 days | L2 |
| Ad hoc | < 2 hrs | < 24 hrs | L3 |
| Events | < 1 hrs | < 3 hrs | L4 |

### Standardisation

For the implementation of RW measures the (national) standards from CROW are applied. Sometimes small deviations from this standard are made. These are related to practical or visual aspects.

Since the city uploads its digital information to the NAP, no specific standards are used.

**NDW:** During the summer and fall of 2025, the NDW set up a reporting point to report on roadworks not well represented in the navigation services of service providers. Road authorities, road users and service providers, could report discrepancies they saw. The reason for this, is that a lot of huge road works were planned during this period.

When a discrepancy was reported, NDW did an analysis on what was the root cause of this. This led to several interesting observations. Sometimes, the cause was on the side of the road authority and/or NDW, sometimes a service provider did not process the provided information on road works correctly.

Another check has been done by using a tool called **RouteRadar**. This tool was developed for Rijkswaterstaat but is now more widely used. For every time interval, the navigation advice for certain Origin-Destination relations and the rerouting tipping points are logged automatically. This provided also very fruitful insights.

### *Source Data Quality & Coverage*

Sources offered by the Dutch National Access Point (NAP) towards the service providers:

- MELVIN, used for road works
- IDEA, real time information about actual traffic on planned road works.
- IM backbone provides information about incidents on the roads. A dashboard (DAISI) is provided with this information.

NDW covers all Road Authorities (RA) in the Netherlands (>300). They put their road works in either MELVIN, LTC Andes or SPIN. In the NDW backbone these sources are combined and are validated with other sources.

Data is distributed only using the DATEX II v3 format.

NDW is developing a quality dashboard for roadworks. (V2 in figure 18) This will be live in Q2 2026. A preview is shown below. The dashboard shows that data quality and coverage is generally high in the Netherlands. The dashboard will help RA's to further improve their road works inputs.

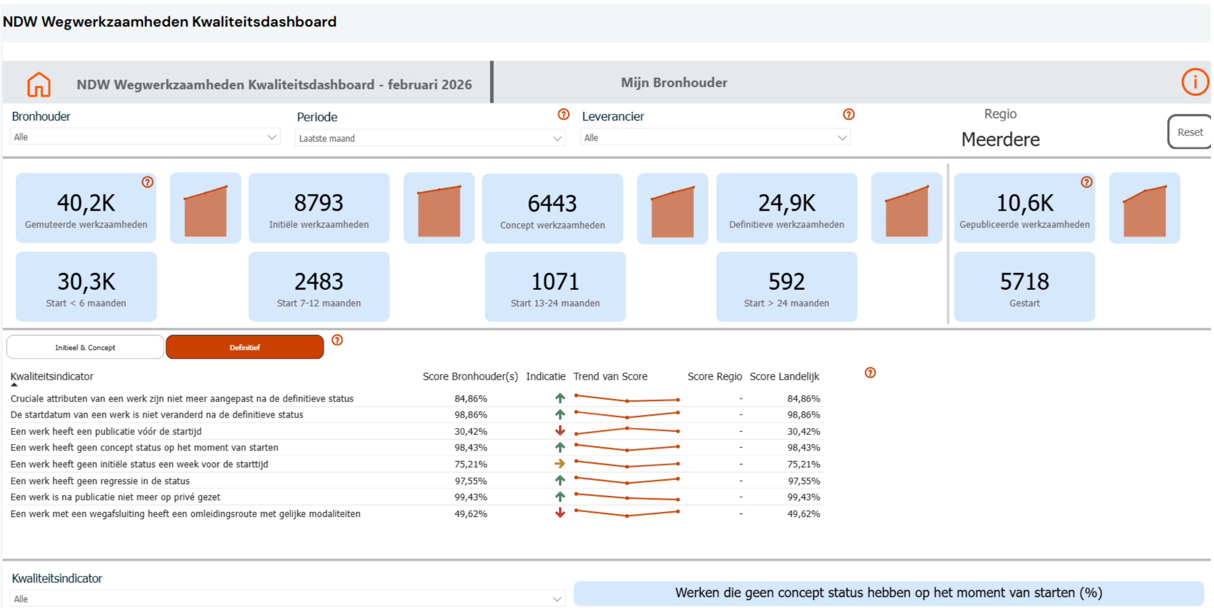



*Figure 19: NDW quality dashboard for roadworks*

For IDEA application (validation of planned road works) Floating Car Data (FCD) of Be-Mobile is used.

Considering, the development and standardisation of feedback from service providers and end users: NDW now receives feedback from service providers (mostly crowd sourced incidents). NDW incorporates this into their data backbone for validating purposes.

We are working on completing an FCD algorithm (IDEA).

### *E2E Process Effectiveness*

**AMSTERDAM** : The 13-step Amsterdam approach ensures a high-quality end-to-end (E2E) process as applied within the Netherlands. The City of Amsterdam's application, Victor, is used for the following purposes:

- A roadwork request can be submitted via the application.
- As part of this request, a BLVC plan is mandatory to ensure:
    - Accessibility for traffic
    - Livability
    - Safety
    - Proper coordination of activities
- Formal approval by the City of Amsterdam is required.
- Only after this approval has been granted is the roadwork registered by Amsterdam.
- The roadwork is subsequently validated in *MELVIN*.
- Following validation, the roadwork is forwarded to the service provider.

**HELMOND:** The flow shows a high level of robustness. We observe that some SP's do not use the data provided by the NAP.

The city has no direct and/or formal relation to the SP's. Annex B – Example Validation & Improvement Patterns

**NDW:** There are several improvements needed in the E2E process. Making improvements in the E2E process, including increasing the data availability and quality on a national level in the Netherlands is also one of the major goals of the programmes ARAMIS and KLA. The goal of the KLA is also to come to structural implementation on a national level, so that the transition towards digitial road management is assured.

Overall, we want to implement automatic data validation (along the three mentioned layers), implement quality KPI's in line with the TISA 5-Star Specification and install a public private feedback loop on data quality.

### *Structural Gaps & Bottlenecks*

**AMSTERDAM**

- Changes in the start and end time of the roadworks are not properly submitted to the Datex v3-output feeds.
- At present, certain road closures are not inserted in *MELVIN*, including:
    - Minor temporary road obstructions (e.g. moving vehicles)
    - Small-scale, one-day events such as markets
    - Emergency road closures

**HELMOND**

- Most important is that we do not have means to validate the start- and end-time. While the start time appears less critical, because it normally is close to the programmed time, this is not the case for the end-time. There are several methods to improve on this issue e.g.:
    a. A message service where the contractor(s) can send a message (e.g. SMS) that automatically ends the measure in the system.
    b. Contractors that have limited access to the system by which they can start and end the measure.
    c. The use of road works warnings signs, that disseminate messages (start/end time) when activated alongside the road (Heijmans infrastructure company has done pilots with this, or like Autobahn and ASFINAG do this with ITS-G5).
    d. Feedback from data providers.
- Currently Helmond uses the LTC Andes system. We may want to use the MELVIN system (provided by NDW). However, the data migration appears to be costly. The 100-150 planned road works entered via LTC cannot be edited by MELVIN. They must be entered manually *again* via MELVIN. This fact is confirmed by NDW. The practical advantages of the Andes system compared with MELVIN are:
    a. The GUI is more flexible: diversion routes can be shown in different colours.
    b. The system gives a better overview.
    c. The public pages of the Andes are designed for colour blind people.
    d. The public pages are better suited for the public, while MELVIN is rather technical.

**NDW**

- The active status monitoring by road authorities is missing. This way an important source of feedback is ignored. DAISI or another dashboard tool could fill in this gap, also for roadworks.
- Consistent use of IDs for events (when changing an event, it must not become a new event with new ID, but the already existing event should be adjusted).

- The process of input, activation and validation needs some more detailed support in Melvin.
- Melvin is not always well aligned with other systems, like LTC.
- The system can be extended with extra sources in a kind of clustering algorithm. This way the information of road contractors, road equipment and signing, or even a direct correction by road authorities can be incorporated.
- KPI calculations are not performed on a regular basis. This must be developed. Mainly the detection of missing values will have to be investigated.
- The process of root cause analysis is not tuned well yet. Problem management of the data chain is not well arranged yet. The first steps will be correlation of flaws in the IDEA algorithm and source data quality.
- Currently, Road authorities cannot distinguish between authoritive road works.
- The current IDEA algorithm refinement needs to be completed.
- Better detection of unplanned road works.

### *Key Risks & Dependencies*

- Data entry in *MELVIN* is performed manually by an Amsterdam employee. As a result, errors and inaccuracies may occur.
- Following the approval of a roadwork, subsequent changes may arise. These changes must also be entered manually into the *MELVIN* application. There is a risk that this step may be overlooked.
- At present, the City of Amsterdam has no insight into how quickly service providers retrieve data from *MELVIN*.
- Strong dependence on the SP's, whether they actually use the data.
- Lack of feedback from the SP's. Also: if such feedback is available, what's the data quality and availability?
- It could be a problem to identify road works if no planning information is available.

### *Priority Improvement Areas*

- Currently, minor temporary road obstructions (such as moving vehicles) are not registered in *MELVIN*. A project is planned to establish an automated interface between the Amsterdam permit system and *MELVIN*. The *MELVIN* API is currently under development to enable this integration.
- Within NDW, validation tools are being developed around the *MELVIN* application.
- The City of Amsterdam may submit a request to NDW to implement start and end point functionality within *MELVIN*.
- Amsterdam is also exploring the possibility of allowing contractors to enter data directly into the *MELVIN* application. The advantage of this approach is that road works would be registered at source, potentially reducing the risk of errors.

- Automation of TISA 5-star KPI calculation. This is necessary to engage the continuous improvement of the data.
- The implementation of the root cause analyses process to be able to pinpoint the main improvements in the data chains.

### *Recommended Actions*

- Create a feedback loop towards the road authorities, for improving the quality of MELVIN data.
- To investigate if we can improve the process on timeliness, especially to demand feedback from the contractors for the start and end-times, in order to reach at least RTTI-5* L3.
- Further elaborating the IDEA-algorithm
- Exploring the added value of additional sources for road works validation
- Consistent use of ID events
- Improvements on MELVIN (e.g. adjustment of start and end time)
- Exploring possibilities to align with activated TMMs (e. detours) as means of validation.
- Building a KPI dashboard based on TISA 5-star specification and for RAs to know where to work on data quality improvement.

### *Best practices*

**AMSTERDAM**: There are already some best practices implemented by NDW for the Netherlands, like IDEA and some quality checks.

From Amsterdam, it is recommended to enter roadblock data as much as possible into the NAP application, as much as possible at the source.

**HELMOND**: We advise other countries/road managers to address the following aspects:

- Implementation of a process from design via approval to publication of the measures.
- Good tooling (see MELVIN, LTC Andres and similar).
- A clear distinction between responsibilities (systems) of the NAP and the local road authority.

**NDW:** As NDW, we would like to advise other countries to:

- Use FCD for road works validation (IDEA)
- Use the principle of a backbone to merge different data sources
- Work with national tooling to collect planned road works.

### 13.8.3 Road closures & Lane closures

For road and lane closures, the earlier general principles are valid as well. In this paragraph we only described what is additional needed for this use case, besides the more general process improvements described in the previous paragraph on road works.

The current E2E process is as followed:

1. **Input & Gathering**: Data is via Contractors, TMC, Road personnel and private data sources such as Crowd sources data, Floating car data and Probe vehicle data.
2. **Active status monitoring:** The data are presented in DAISI to road authorities and operational personnel. In the DAISI tooling they can give feedback on the situations, for example if it the situation really is happening.
3. **Ground truth comparison:** The data in the database are cross compared with a clustering and fusion algorithm. Providing an estimation of probability that closure really is there.
4. **Publication**: Once released, data enters NDW's 'Afsluitingen' (road closures) product, which is currently distributed in standardized DATEX II v2.3 and DATEX II V3 format, and starting from April 2nd, 2026, will only be distributed using the DATEX II v3 format.
5. **Access & Delivery**: The data is delivered via NDW's open data portal. NDW open data

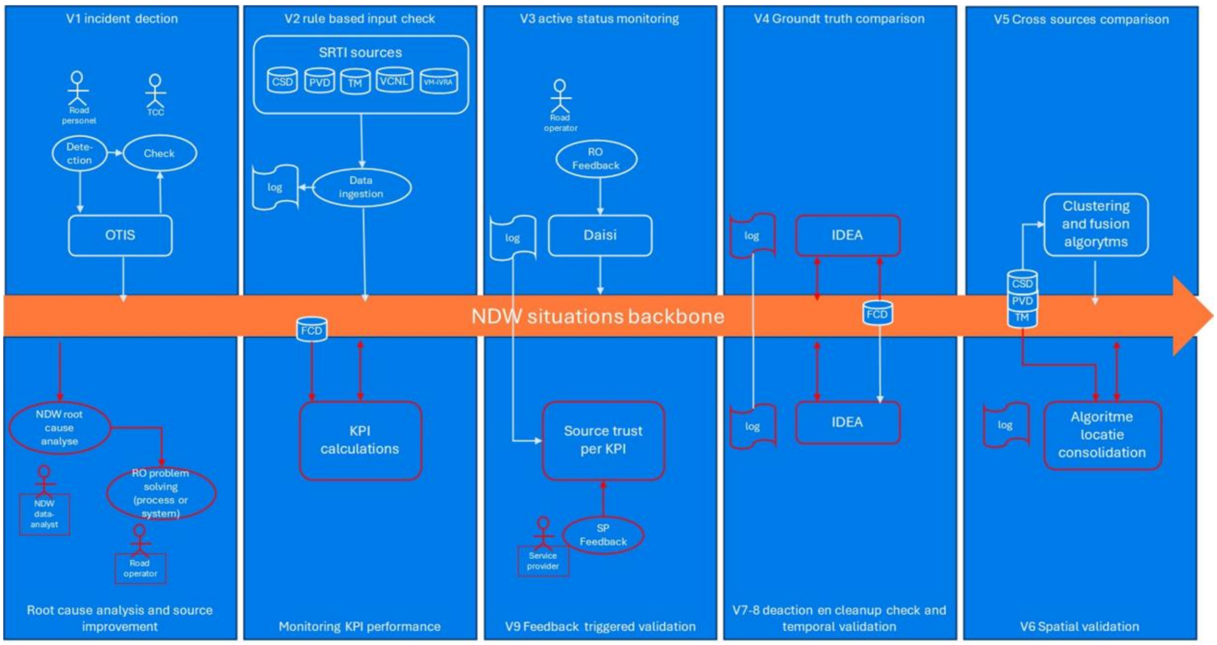



*Figure 20: Target NDW E2E process Road Closure & Lane Closure:*

The picture above is the E2E process that we want to strive for. The end-to-end process is a collaboration of road authorities and NDW. It is mostly the same as in Figure 18 at

Roadworks. It has the same different layers of validation, but the used sources and processes for obtaining the situations are different. The proposed validation techniques are similar but the components in place (white) and still to be implemented (red) are different than in the figure of roadworks

Other improvements that we see for road and lane closures:

- The active status monitoring by road authorities is missing. This way an important source of feedback is ignored.
- The road closures can be extended with the IDEA algorithms that already is functional for roadworks. This will be a large improvement in the plausibility calculations of the situation.
- KPI calculations are not performed on a regular basis. This has to be developed. Mainly the detection of missing values will have to be investigated.
- Anomaly detection based on FCD for example, is seen as an important extra source for detecting situations on the secondary roads, where no direct monitoring of incidents is possible.
- The process of root cause analysis is not tuned well yet. Problem management of the data chain is not well arranged yet. The first steps will be a correlation of flaws in the IDEA algorithm and source data quality.

***Best practices***

Invest in transparent data driven statistical models based on multiple data sources. The combination of these data may lead to better quality despite ground truth data is missing in most situations.

***Recommendations towards WP4 – WP5***

The output of the public private feedback loop on data quality, is a very valuable source for validation road works and road and lane closures on the NDW situations backbone.

## 13.9 Slovenia - Key observation

### 13.9.1 Slovenia – Road works, Road Closure & Lane Closure

***High Level Description of current E2E process & tools used***

**National Road Closure Register (NEZ)** is a web application that enables all managers of the transport network and infrastructure to access and share information about road closures caused by construction works, maintenance, events, or emergencies.

The application is designed for easy use. Closure data is displayed on an interactive map, allowing a quick overview of the transport network and simple entry of planned closures.

NEZ connects all levels of managers—such as DARS (motorway company), DRSI (Slovenian Infrastructure Agency), Slovenian Railways, and municipalities—and enables more efficient and coordinated planning of closures.

The NEZ platform enables:

- collection and display of data on maintenance works that require planned closures,
- collection of data on exceptional transports,
- simulation of closure impacts based on a traffic model and optimization of measures,
- public publication of planned and current closures.

The system allows data exchange with external stakeholders' information systems, including:

- local community data on closures,
- the VGRC information system for documenting maintenance and construction on regional roads (used by local communities),
- the KAŽIPOT information system for collecting data on road works for the traffic information center,
- the system for exceptional transports used to record applications for special transports,
- data on work-related closures carried out by Slovenian Railways.

Reliable and up-to-date data is also sent to the NAP in DATEX II v3.3 format.

Data on closures in NEZ will be used to analyse the impact of closures on traffic flows. The impact is assessed using the national traffic model. The dynamic traffic model calculates traffic forecasts for the duration of individual closures and predicts the effects of one or more closures on traffic. Visualization of analysis and simulation results will show the impact of individual closures or measures on traffic flow and enable optimization of measures.

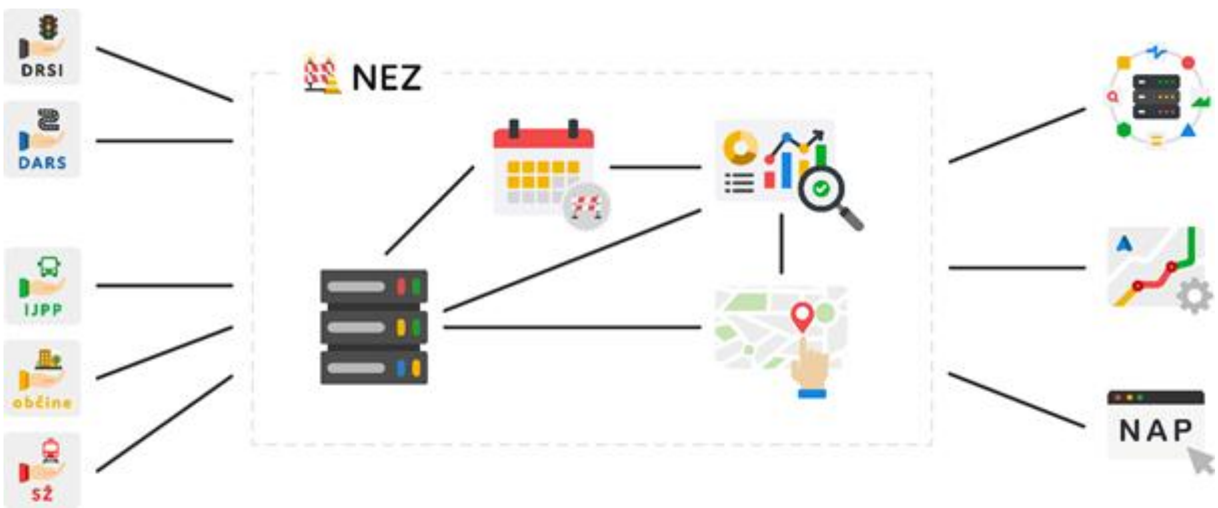



*Figure 21: Slovenia High Level Architecture*

### *Current Service Performance*

Road closure data is available as live feed on NAP.

All the info is published in real time on official TIC platform and app.

The live feed is used by WAZE. The other service providers publish some of the information, but not promptly.

### *Source Data Quality & Coverage*

Data is provided by road operators. At the moment national roads and highways are covered.

The data is published in real time on NAP in DATEX II v3.3 format.

### *E2E Process Effectiveness*

The data flow from source to publication is effective. All the steps are confirmed by the staff and published on trustworthy channels.

### *Structural Gaps & Bottlenecks*

The validation process is weak.

### *Key Risks & Dependencies*

Validation is performed only as a feedback on the official platform.

Municipalities are not obliged to share the data about RW.

### *Priority Improvement Areas*

Adapt the validation process with dynamic traffic model (FCD included) and automated feedback loop.

Unite all the RW data in one register including municipal roads.

### *Recommended Actions*

- Optimization of the RW planning concerning mutual impact between different closures.
- Upgrade and automation of the validation process.
- Request the municipalities to use the national register.

***Best practices***

It is beneficial if the road closure platforms are connected (or integrated) to the platforms that road managers use for maintenance planning of road network.

Road closure platforms should also enable the publication of standardised data on NAP's. However, it is also useful to be able to manually control the publication of this data if some corrections are needed.

## 13.10 Spain - Key observations

### 13.10.1 Spain Road works

***High Level Description of current E2E process & tools used***

Information relating to road works follows the workflow described below, involving various actors and applications:

**Step 1. Communication of road works to the Dirección General de Tráfico (DGT)**

Once the road authority has authorised the works, the contractor notifies DGT via the TRAZA[1] application to obtain the corresponding traffic management instructions (IRT), which set out the restrictions and regulatory measures to be considered whilst the works are being carried out.

Attached to this notification is the authorisation from the road authority; depending on the type of road works, the following details are also provided:

- General road works: the road authority grants authorisation for one year and for roads under its jurisdiction within a province, specifying this information.
- Specific road works: duration of the road works (date and hours), the road and the kilometre points affected.

The notification is recorded in TRAZA with the status "Pending validation".

**Step 2. Validation and authorisation of communication in TRAZA**

[1] TRAZA is a system designed primarily for managing permits for special transport, sporting events, film shoots and road works.

The corresponding Traffic Management Centre (TMC) receives the communication via TRAZA. A TMC operator reviews the request and, if it is correct, validates it and changes the status in the application to "Validated".

The head of the TMC receives requests with the status "Validated" and, if appropriate, authorises them, changing the status of the request to "Authorised".

Step 2.a. General road works

Once the notification has been marked as "Approved", the relevant IRT is issued; however, its validity is subject to the notification of the start of works being submitted via the RENO[2] application.

Step 2.b. Specific road works

Once the notification has been marked as "Approved", the relevant IRT is issued; however, its validity is subject to the notification of the start of works being submitted via the RENO application. In addition, information about the road works is sent to LINCE[3], where it remains in "Forecast" status, shown with a dotted line and in yellow, until the actual start of the works is notified.

**Step 3. Notification of the start of road works via RENO (current process)**

The contractor must confirm via the RENO application that road works have commenced as soon as traffic is affected. This confirmation involves specifying the exact location affected by the road works and the duration of the traffic disruption, by activating the road status in RENO. In the case of mobile road works, the person responsible for the works must keep the details of the location and timing of the disruption updated via RENO.

This notification is linked to a TRAZA authorisation; a password and authorisation ID will be provided in this application at the end of the road works notification process, so that the start and end dates can be reported to RENO.

---

[2] RENO is the app designed for managing information on road works.

[3] LINCE is the incident management tool (Localizador de INcidencias en las Carreteras Españolas).

Step 3.a. General road works

Once the start of a general road works has been confirmed via the RENO application, the road works event becomes active, and this traffic incident is displayed in LINCE as an “Event”.

Step 3.b. Specific road works

Once the start of a specific road works has been confirmed via the RENO application, the road works event becomes active; as a result, the traffic incident previously recorded in LINCE as a “Forecast” is reclassified as an “Event” and is displayed with a solid line.

In both cases, the contractor must manually report the completion of the road works via RENO.

Step 3bis. Notification of the start of road works using connected cones (currently being developed)

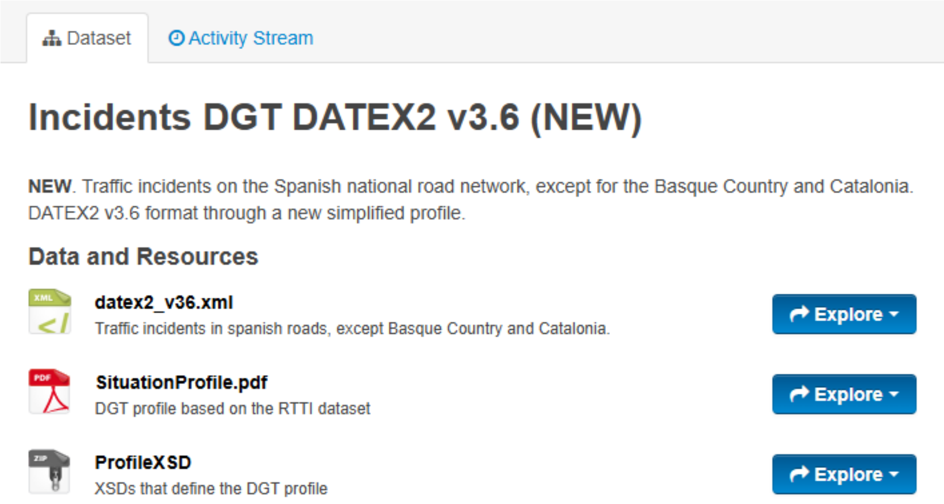
The contractor confirms the start of road works by switching on the connected traffic cones as soon as the disruption to traffic begins. In this case, confirmation involves placing the switched-on connected traffic cones at the start and end of the section affected by the road works. In the case of mobile road works, the person responsible for carrying out the works must not update the details of the location and time of the disruption via RENO but must instead move the connected cone to the relevant location.

The cone will send as many messages as the beacon remains active, with a frequency of 5 minutes between messages. Finally, the cone will send a single shutdown message confirming the end of the road works.

The information from the connected cone is collected on the DGT 3.0 platform, which sends it to LINCE.

**Step 4. Publication of LINCE information on the NAP**

Information relating to road works stored in LINCE is also published on the NAP (https://nap.dgt.es/en/dataset/incidencias-dgt-datex2-v3-6) in DATEX II v3.6 format every minute.


Dataset
Activity Stream

## Incidents DGT DATEX2 v3.6 (NEW)

**NEW**. Traffic incidents on the Spanish national road network, except for the Basque Country and Catalonia. DATEX2 v3.6 format through a new simplified profile.

### Data and Resources

**datex2_v36.xml**
Traffic incidents in spanish roads, except Basque Country and Catalonia.
Explore

**SituationProfile.pdf**
DGT profile based on the RTTI dataset
Explore

**ProfileXSD**
XSDs that define the DGT profile
Explore

Also, the data is published through a traffic map called eTraffic.

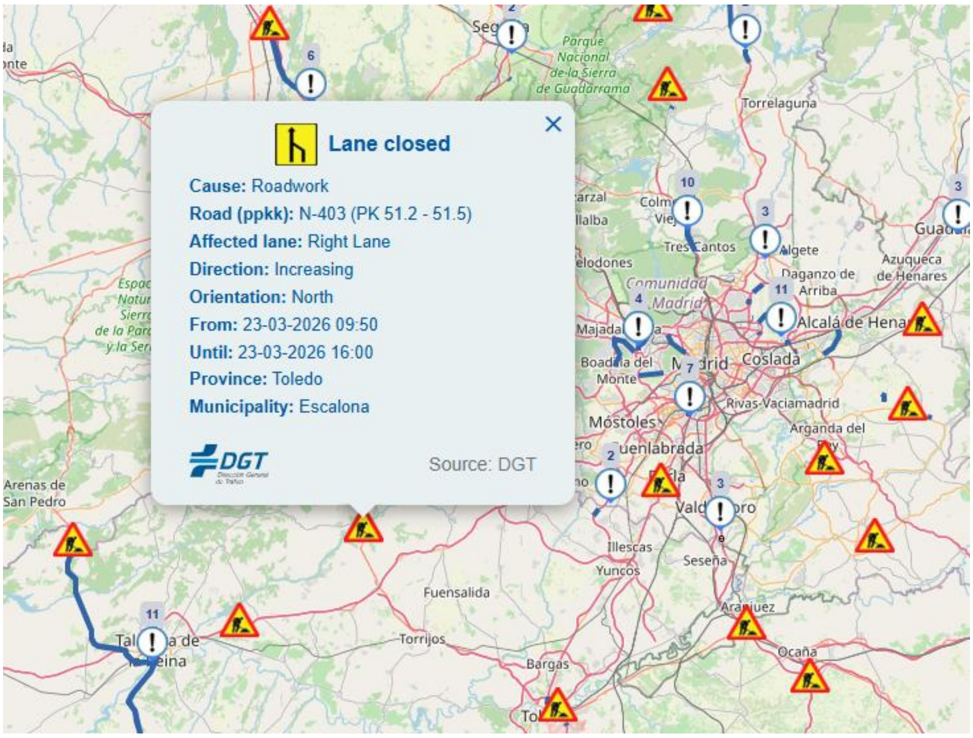



*Figure 22: Spain - eTraffic Representation*

### Step 5. OPTIONAL – Validation of ongoing road works

Whilst road works are in progress, their progress can be monitored using TMC’s equipment, via the Traffic Police, or through information received from Waze.

Complete ecosystem:

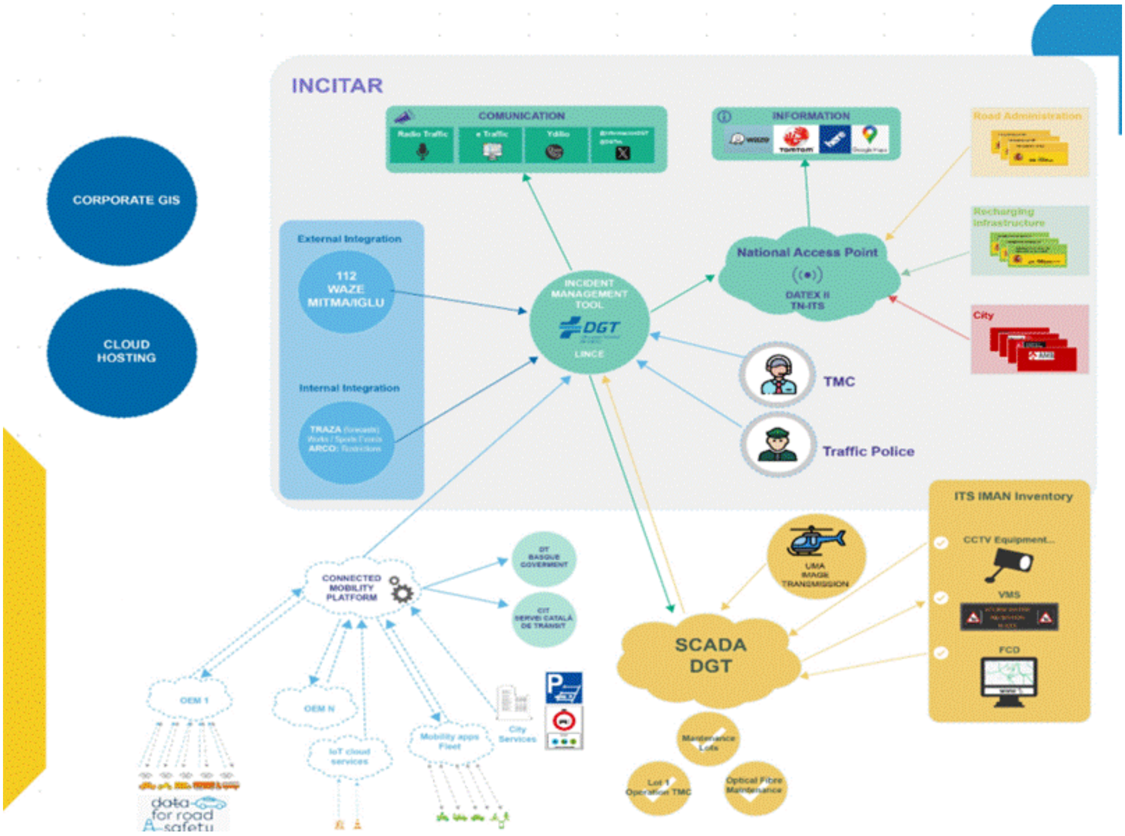



*Figure 23: Spain - Complete ecosystem*

### *Current Service Performance*

All above-described road works info is available on the Spanish NAP in Datex-II v3.6 format every minute.

This is open data, we have no tracking on who is consuming what.

WAZE has a direct access of the information through LINCE and is consuming the information.

The data is also published through our traffic map (eTraffic) available in the following link: https://etraffic.dgt.es/etrafficWEB/

### *Source Data Quality & Coverage*

**Sources of information**

Information regarding road works is primarily collected from contractors via TRAZA and RENO applications.

This information is fairly accurate, although there may be some variation between the time when road works begin and the time when their start is notified, as this is a manual process. If road works can't start when planned, contractor normally inform TMC.

However, there are other sources that are also used in the data validation process:

- Information from Waze. It may provide information that was not previously taken registered, but its level of completeness is different as it lacks road status (WAZE no notify and validate events), which could be covered by the TMC
- The TMC via ITS equipment (cameras) and aerial surveillance
- Traffic police (ATGC)

All the information is collected in the LINCE application, and it is published on the NAP in DATEX II v3.6 format every minute.

**Coverage:**

In theory, all road works should be officially registered, regardless of who are responsible of the maintenance of the road. In practice, sources such as Waze, TMC equipment or the traffic police detect some that have not been registered correctly or not reported.

Traffic police can stop road works if not reported action has been taken or fine if IRT is not followed.

Complete and validated information is available on the road works being reported.

#### *E2E Process Effectiveness*

The process, from data collection to publication, is effective, but it depends on the RA and contractor's commitment to ensuring that the information is reported correctly.

#### *Structural Gaps & Bottlenecks*

Validation/authorisation of road works to provide the IRT is carried out manually, which can lead to a bottleneck if the RA or contractor send it very close to the beginning of the road works.

#### *Key Risks & Dependencies*

The key issues that have been detected are:

- Some RA and contractors don't provide the data on time and form in TRAZA.
- There is a lack of communication about the start of road works, which are sometimes identified using information from external sources such as Waze, via TCM equipment (cameras) or through the traffic police.
- Some service providers sometimes use inaccurate information, as sometimes do not use the information published on the NAP.

*Priority Improvement Areas*

- To improve communication about the start of road works using connected cones.

*Recommended Actions*

The same as the Priority Improvement Areas

*Best practices*

Use of IoT devices which provide accurate data.

## 13.11 Sweden - Key observations

### 13.11.1 Sweden – Road works

*High Level Description of current E2E process & tools used*

The Swedish Transport Administration (STA, Trafikverket) initiate the need for long term road works. After a procurement process, an agreement with one contractor is made and data connected to the planned roadwork is collected (the measure, when, where, etc.). The data is then stored in a specific database and additional data from eg our National Road Database is added. When it is time to start the actual work, the contractor is obliged to continuously send in data on when and where the work is ongoing, this fails quite often. Short-term road works can be initiated by STA or a contractor or another external stakeholder. The obligation to report when and where a short-term roadwork is ongoing still apply. No real automatic validation is done. Temporary traffic regulations or restrictions are often connected to a roadwork.

The people working operational in the Traffic Management Centre (TMC) need to manually validate and confirm road works-info before a DATEX-message is created and provided to external stakeholders. In parallel, everything that are provided to external stakeholders, are stored in our database for historic traffic information.

For some areas, including parts of the Gothenburg area, STA buys travel time data in real time from Inrix. The purpose of this data feed is primarily variable sign messages and real time traffic status in maps but also for analysis. The Inrix data feed is fused with sensor data from STA in an internal system. In parallel, STA is evaluating travel time data from Tomtom.

*Current Service Performance*

Most road works on state roads are shown in navigation services, but quite often it is actually planned road works that are shown resulting in false positive. A roadwork is ongoing only for part of the time and part of the length where it is planned. Most municipality roads and streets lack information on road works. We have some ad-hoc follow-up on how Service Providers use our data.

### *Source Data Quality & Coverage*

Source data quite often lack positional accuracy and timeliness even though the overall coverage and completeness for state roads is OK.

### *E2E Process Effectiveness*

We have a working data flow from source to publication, transformation between formats and publication work quite well, validation is not robust enough.

### *Structural Gaps & Bottlenecks*

No efficient way to get continuous updates from contractors regarding where and when they actually work on the road. Lack of automatic validation. No formalized follow-up of incoming data, the process, the provided data and how the data is used by Service Providers. No structured interaction with Service Providers to get feedback on our provision of road works-info. In the first step, logical issues in the external data flow should be addressed and eliminated.

### *Key Risks & Dependencies*

Difficulties to get up-to-date data from contractors. Internal legacy systems handling road works-data, these systems are not built to contribute to quality assured traffic information.

### *Priority Improvement Areas*

Set requirements on contractors to deliver up-to-date data. Automatic validation. Structured dialogue with and feed-back from Service Providers.

### *Recommended Actions*

The same as the Priority Improvement Areas.

### *Best practices*

Follow-up and analysis of how different Service Providers interpretate and use the information we provide gives valuable input to get an understanding of current issues and problems.

### 13.11.2 Sweden – Road Closure – Lane Closure

***High Level Description of current E2E process & tools used***

Temporary traffic regulations or restrictions as closed road or closed lane is often connected to a roadwork. Closing a road is often planned in detail in advance and this makes it possible for the TMC to provide high quality data on exact position, start-time and end-time in advance. Emergency closures need to be validated and confirmed by people at the TMC. Sometimes we have issues confirming exact location of these closures. Creation of DATEX-message, provision to external stakeholders and storing in our own database is the same as for road works-info. Closed lanes are often not provided explicitly, but rather as “limited accessibility”.

***Current Service Performance***

Most road closures on state roads are shown in navigation services, lane closures are often not shown. Road closures on municipality roads and streets might be shown in navigation services but we don’t have the full picture. Lane closures are not shown. We have some ad-hoc follow-up on how Service Providers use our data.

***Source Data Quality & Coverage***

Source data sometimes lack positional accuracy and timeliness for road closures, even though the overall coverage and completeness for state roads is OK. Lane closures are not handled properly.

***E2E Process Effectiveness***

We have a working data flow from source to publication, transformation between formats and publication work quite well, validation is not robust enough.

***Structural Gaps & Bottlenecks***

Updates from contractors on road closures are better than general information on actual road works. The source of planned road closures can be internal and then with higher quality, still lack of automatic validation. No formalized follow-up of incoming data, the process, the provided data and how the data is used by Service Providers. No structured interaction with Service Providers to get feedback on our provision of road closure info. Lane closures are not handled properly at all.

***Key Risks & Dependencies***

Internal legacy systems handling road closure- and lane closure-data, these systems are not built to contribute to quality assured traffic information.

### *Priority Improvement Areas & Planned Actions*

Set requirements on contractors to deliver up-to-date data. Automatic validation. Structured dialogue with and feedback from Service Providers.

### *Best practices*

Follow-up and analysis of how different Service Providers interpretate and use the information we provide gives valuable input to get an understanding of current issues and problems.

# 14 Annex B – Self Assessment Manual 5-Star Rating

## 14.1 Introduction

In the TISGRADE project, Be-Mobile will support in the set -up of a strategy or methodology for the validation of datasets containing information about

- Planned road works (RW)
- Unplanned road works
- Planned Lane closures (LC)
- Unplanned lane closures
- Maximum speed limits

(Note that a full road closure is seen as a special case of lane closure).

This validation methodology will be based on the TISA 5-star rating methodology, where we are exploring the possibility of developing a fully automated, semi-continuous validation service which keeps the 5-star rating of any given dataset(s) up to date at all time, ensuring they are suited for distribution on a NAP, take-up by service providers, etc.

## 14.2 Self-assessment 5-star rating methodology

As a first step towards a process for such as a fully automated, semi-continuous validation service, we have set up a ***self-assessment 5-star rating*** in the form of a fill-in Excel worksheet (“5-star_rating_self_assessment.xlsx”) which automatically calculates the 5-star rating for the given dataset. This chapter serves as an explanatory guideline for using this worksheet.

First, note that the filling in of this worksheet may require input from the entire PDV ecosystem, e.g. it may not be possible to be performed only by the Road Authority without involvement of the NAP. Secondly, the goal of a 5-star rating is solely to *gauge the quality of the dataset itself*, with the purpose of being used by service providers to enhance the safety and user experience of their services. It does not take into account any *effectiveness* of the dataset to achieve this goal, only its *potential*. For example, optimized intelligent planning is essential for achieving safe road works with minimal impact. The 5-star rating however has no knowledge (and doesn’t require it) about whether this step was successfully performed before creating e.g. a dataset containing planned roadworks data.

In the current version of the TISA 5-star rating (see https://tisa.org/rtti-5-star-rating-specification/), the following criteria are defined for datasets about roadworks and lane closures:

| *Criterion name* | *Road works (RW),*<br><br>*lane closure (LC) or Maximum Speed Limits (MSL)* | *Analysis type* |
|---|---|---|
| ***Terminology & Definition*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>MSL | Real-time desk |
| ***Data Format Used*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>MSL | Real-time desk |
| ***Use of Specification*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>mSL | Real-time desk |
| ***Location Referencing*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>MSL | Historical desk |
| ***Linear Referencing*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>MSL | Historical desk |
| ***Direction Defined Functional Road Class 3-6*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>MSL | Historical desk |
| ***Update Cycle*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>MSL | Real-time desk |
| ***Timeliness*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>MSL | Ground truth |
| ***Functional Road Class 1-4***<br><br>***Accuracy***<br><br>***Correctness*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>MSL | Ground truth |

| | | |
|---|---|---|
| ***Functional Road Class 5-6***<br><br>***Accuracy***<br><br>***Correctness*** | Planned RW<br>Planned LC<br>Unplanned LC<br>MSL | Ground truth |
| ***Completeness*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC<br>MSL | Ground truth |
| ***RTTI Event Message ID*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC | Historical desk |
| ***Secure API Access*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC | Real-time desk |
| ***Outdated Messages Deleted from Feed*** | Planned RW<br>Unplanned RW<br>Planned LC<br>Unplanned LC | Real-time desk |
| ***Availability Short Term Events*** | Planned RW<br>Unplanned RW | Real-time desk |
| ***Road Type*** | Planned RW<br>Unplanned RW | Historical desk |
| ***Validity*** | Planned RW<br>Unplanned RW<br>Planned LC | Real-time desk |
| ***Vehicle Classification*** | Planned RW<br>Unplanned RW<br>Unplanned LC<br>MSL | Real-time desk |
| ***Cause type*** | Unplanned LC | Real-time desk |
| ***Speed limit type*** | MSL | Real-time desk |

*Note: OpenStreetMap (OSM) highway keys are used as Functional Road Classes (FRC)*

Each of these criteria needs to receive a score (1-5) in order to calculate the final 5-star rating in the self-assessment worksheet. The criteria are divided into three categories: real-time desk analysis, historical desk analysis and ground truth analysis, and will be discussed separately in the next subchapters.

## 14.3 Desk analysis: Real-time

Real-time desk analysis can be performed in real-time, each time the feed source updates its content. Typically, it can be performed automatically by a machine. In this self-assessment, of course, it only needs to happen once for each dataset and can thus also be assessed manually. Below, the assessment of each related criterion is described in more detail.

### 14.3.1 Terminology & Definition

*From the TISA documentation:* This is the use of clearly defined and harmonised terms across all datasets. Prevents misinterpretation and ensures consistency between parties. Higher scores ensure maximum up-take and, where applicable, adhering to the law.

Example: Use 'roadClosure' instead of 'incident'. In short, this criterion checks the correct use of the DATEX II terminology (**field names**) by comparing with the DATEX II reference profiles on https://docs.datex2.eu/v3.3/reference_profiles/rrp/index.html.

### 14.3.2 Data Format Used

*From the TISA documentation:* The technical structure in which the data is provided. Determines compatibility with processing systems. Standard formats reduce data parsing errors and allow fast integration into (existing) workflows. The risk with a local format is that not all information is filled in hence context might be wrong or open for misinterpretation.

Example: Closure event published in DATEX II v3 XML. This is a simple yes/no criterion checked by verifying the format type.

### 14.3.3 Use of Specification

*From the TISA documentation:* Whether the format or method aligns with a recognized specification. Specifications used ensure interoperability across platforms. Specification use guarantees predictable structure, speeding up validation and quality checks and allowing these checks to be recurrent without change.

Example: Road Closure feed uses DATEX II v3 with correct structure. In short, this criterion checks the correct use of the DATEX II specification (**field content**). This can be checked with a useful tool on https://docs.datex2.eu/v3.3/ravtestcentre/.

### 14.3.4 Update Cycle

*From the TISA documentation:* Frequency with which the data source updates its content.

Ensures that changes are reflected promptly. Higher update frequency reflects real-time conditions more accurately.

Done by checking the presence of 'last update' / 'updated since' in the data feed. And compare that with the now(). Even if the data appears unchanged to a day earlier the 'last update' value confirms that the source has been updated with the latest and greatest information.

### 14.3.5 Secure API access

*From the TISA documentation:* Whether access to the data feed is encrypted and authenticated. Prevents unauthorised access and data tampering. Higher security increases trust.

Example: Feed URL uses https://. The data feed must use HTTPS or equivalent encryption. This can be validated by checking the protocol and validating the SSL certificate.

### 14.3.6 Outdated Messages Deleted from Feed

This criterion verifies whether there are no outdated events present in the feed, i.e. with an end time in the past.

### 14.3.7 Availability Short Term Events

*From the TISA documentation:* Presence of temporary disruptions (e.g., sudden road works) in the feed. Ensures urgent events are communicated rapidly. Improves response to critical but short-lived incidents, supporting real-time rerouting.

A simple yes/no criterion which can be verified with the data source supplier.

### 14.3.8 Validity

This criterion checks whether start/stop times and schedules are available. In the feed.

Example: "Closure active from 2025-12-01T08:00 to 2025-12-01T18:00 or schedule: Mondays 08:00-16:00".

### 14.3.9 Vehicle Classification

*From the TISA documentation:* Whether data includes vehicle-type relevance (e.g. cars, buses). Ensures speeds and routing are correctly applied per vehicle type. Enables personalized navigation and compliance with legal and routing restrictions.

Example: "Closure applies only to vehicles >3.5t". This is checked by verifying the presence of the vehicle type attribute in the data feed.

This is evaluated according to the following vehicle-type categories:

| Category | Description |
|---|---|
| **L** | Motor vehicles with less than four wheels [but does include light four-wheelers] |
| **L1** | A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine not ex-ceeding 50 cm³ and whatever the means of propulsion a maximum design speed not exceeding 50 km/h. (Electric bicycle) |
| **L2** | A three-wheeled vehicle of any wheel arrangement with an engine cylinder capacity in the case of a thermic engine not exceeding 50 cm³ and whatever the means of propulsion a maximum de-sign speed not exceeding 50 km/h. (Auto rickshaw) |
| **L3** | A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm³ or whatever the means of propulsion a maximum design speed exceeding 50 km/h. (Mo-torcycle) |
| **L4** | A vehicle with three wheels asymmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm³ or whatever the means of propulsion a maximum design speed exceeding 50 km/h (motor cycles with side-cars). |
| **L5** | A vehicle with three wheels symmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm³ or whatever the means of propulsion a maximum design speed exceeding 50 km/h. (Motorized tricycle) |
| **L6** | A vehicle with four wheels whose unladen mass is not more than 350 kg, not including the mass of the batteries in case of electric vehicles, whose maximum design speed is not more than 45 km/h, and whose engine cylinder capacity does not exceed 50 cm³ for spark (positive) ignition en-gines, or whose maximum net power output does not exceed 4 kW in the case of other internal combustion engines, or whose maximum continuous rated power does not exceed 4 kW in the case of electric engines. (Golf cart, Mobility scooter) |
| **L7** | A vehicle with four wheels, other than that classified for the category **L6**, whose unladen mass is not more than 400 kg (550 kg for vehicles intended for carrying goods), not including the mass of batteries in the case of electric vehicles and whose maximum continuous rated power does not exceed 15 kW. (Microcars) |
| **M** | Vehicles having at least four wheels and used for the carriage of passengers |
| **M1** | Vehicles used for carriage of passengers, comprising not more than eight seats in addition to the driver's = 9.( Larger Than Standard Car e.g.: London Cab / E7 Type Vehicle 8 seat + Driver.) |
| **M2** | Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tonnes. (Bus) |
| **M3** | Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tonnes. (Bus) |
| **N** | Power-driven vehicles having at least four wheels and used for the carriage of goods |
| **N1** | Vehicles used for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes. (Pick-up Truck, Van) |
| **N2** | Vehicles used for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes. (Commercial Truck) |
| **N3** | Vehicles used for the carriage of goods and having a maximum mass exceeding 12 tonnes. (Commercial Truck) |

| | |
|---|---|
| **O** | Trailers (including semi–trailers) |
| **O1** | Trailers with a maximum mass not exceeding 0.75 tonnes. |
| **O2** | Trailers with a maximum mass exceeding 0.75 tonnes, but not exceeding 3.5 tonnes. |
| **O3** | Trailers with a maximum mass exceeding 3.5 tonnes, but not exceeding 10 tonnes. |
| **O4** | Trailers with a maximum mass exceeding 10 tonnes. |

### 14.3.10 Cause type

*From the TISA documentation:* Classification of the event cause (e.g., roadworks, accident, weather). Enables better filtering and prioritization, helps understand forecasting a trend. Higher granularity supports user relevance and various treatments in services (e.g. a collapsed bridge will affect throughput for a long time and affect both RTTI and map systems, where a small flooding could be resolved quickly and even occur regularly).

This is done by checking for the 'causeType' attribute in feed (DATEX II) or equivalent in bespoke format.

### 14.3.11 Speed limit type

| ***Speed Limit Type*** | ***Definition*** | ***Example*** |
|---|---|---|
| ***Explicit*** | *Explicit speed limits are clearly indicated by road signs that display a specific speed limit value, such as 50 km/h or 30 mph. These signs are easily visible to drivers and provide a direct instruction on the maximum allowable speed for that section of the road.* | *A speed limit sign on a highway indicating a maximum speed of 100 km/h is an explicit speed limit.* |
| ***Implicit*** | *Implicit speed limits are not directly posted on signs but are understood based on the type of road, road infrastructure, or other contextual cues. Drivers must infer these limits from their surroundings rather than from explicit signage.* | *In many residential areas, there might not be any posted speed limit signs, but drivers are expected to adhere to a standard residential speed limit, which is often lower than on main roads. Similarly, entering a city might imply a lower speed limit compared to rural highways.* |

*Table 12: Speed limit type and definitions (From TISA Documentation)*

This is done by checking in which type speed limits are supplied in the data feed.

## 14.4 Desk analysis: Historical

Historical desk analysis requires a certain number of *stored feed updates* in order to be performed. This historical database can e.g. be present at the source itself (e.g. road authority) or at the data recipient (e.g. a NAP). If it is not, the calculation of a 5-star rating requires the creation a historical database of feed updates first. In any case, in order to perform a correct TISA 5-star rating, it is essential that the historical database comprises of feed updates **as they were (or would be) published on the NAP.**

The size of this historical database depends on the number of events collected over the stored feed updates. For a reliable calculation of the related criteria, we advise using a database containing **at least 100 events** of the given type (planned RW, unplanned RW, planned LC or unplanned LC). This number is a first estimate, and can be changed if practical experience shows that it is needed.

Finally, note that the result of a historically analyzed criterion is typically expressed in percentages. For example, when evaluating the “Location referencing” criterion, one can have 98 events with purely OpenLR referencing, and 2 events with Basic GNSS INSPIRE coordinates, or even invalid ones. By using percentages, we effectively introduce a tolerance to the criterion. In this example, with a tolerance of 2% for location referencing, this criterion score would result in a rating of 5 stars, despite having 2 ”bad” events. **In short, the tolerance on a criterion indicates how many of the “worst scoring events” can be ignored while calculating the criterion score.**

### 14.4.1 Location Referencing

*From the TISA documentation:* How the physical position of the event is described. Critical for correctly placing an event on a digital map. More precise referencing means less misalignment and misrouting, especially in complex networks.

Example: “Closure from km 45.0 to km 47.5” encoded in OpenLR. This is done by checking for the presence of OpenLR or other location referencing.

### 14.4.2 Linear Referencing

*From the TISA documentation:* Linear referencing represents locations as measurements along a linear feature, like a road, using distances or offsets from a known starting point, enabling continuous data representation improves data management, sup-ports dynamic segmentation, and aligns with the linear nature of networks, making it ideal for traffic and mapping systems to efficiently detect and process changes. Better contextual placement of long events like speed limits, road works or closures.

Example: Closure encoded as polyline with start and end coordinates. In practice, this is done by checking whether lines are represented in the polyline structure.

#### 14.4.3 Direction Defined Functional Road Class 3-6

*From the TISA documentation:* Whether the direction of travel is included for lower-class roads. Necessary for correct map matching on bidirectional roads. Reduces risk of misplacement on wrong carriageway or road segment.

Example: "Closure applies only to northbound lanes". Done by checking the presence of a direction attribute (in DATEX II or bespoke format).

**Note: Currently, OpenStreetMaps road classes are used as the definition for Functional Road Classes (FRC).**

#### 14.4.4 RTTI Event Message ID

*From the TISA documentation:* A unique identifier for each event published in the data feed. Essential for tracking, updating, and deleting events throughout systems. Higher scores ensure robust life cycle management of traffic messages including root cause analysis in case of issues.

Example: Closure event ID 'RC12345' remains unchanged through all feed updates where the event is present.

#### 14.4.5 Road Type

*From the TISA documentation:* Classification of the road (motorway, regional, urban, etc.). Some data is more critical or applicable on certain road types. Higher resolution of classification supports tailored data relevance and prioritization.

Done by checking for the presence of a road type attribute.

### 14.5 Ground truth analysis in future automation

The most challenging category of criteria are those that require analysis of the historical database of events against ground truth. The related criteria will not be calculated in the current self-assessment phase due to challenges in data (processing) availability at all PDV's. During the pre-deployment phase, an automatic rating tool will be developed which will be able to calculate these challenging criteria, and full 5-Star Ratings will be calculated.

In this section, we already give a high level, functional overview of how ground truth criteria will be calculated in this automatic tool.

We define "ground truth" as

*A qualitative dataset describing the reality on the road as closely as possible.*

The most obvious way to collect such a dataset is by having a field operator go the location of the event and write down/measure its characteristics (actual start/end time, actual start/end location...). A second option may be static camera-based detection of the event site. This is in practice not feasible to have for the entire historical database of events, which is typically solved by using *sampling*: using a small, random selection of historical events to validate against the ground truth. TISA advises choosing the sample size based on a 90% confidence level with a 5% margin of error, for example:

| Population size (N) | Required sample size |
|---|---|
| 50 | 43 |
| 100 | 74 |
| 500 | 176 |
| 1000 | 214 |

For our advised historical dataset size of 100 events, this means that 74 events need to be validated against a ground truth. When using only field-based inspection to collect this data, this would mean the field operators having visited at least 74 of the 100 events, **as well as monitoring continuously the actual start and end times.** It's clear this is a costly affair.

This is why we suggest **combining** field-based ground truth with other data sources such as Floating Car Data (FCD) and/or Road User Feedback (RUF). The goal of doing this is to both reduce the cost of performing the ground truth analysis required for a 5-star rating and improve the quality of this analysis by increasing the sample size. Note that, even though evaluation against data-based ground truth may not work in all cases, the large increase in sample size means that one generally finds enough validation samples even when omitting such "problem cases".

Obviously, this approach goes with a very strict quality requirement of the given dataset, as we are expecting it to reflect reality on the road as closely as possible. Specifically, FCD and RUF must adhere to the following quality requirements before they can be used for ground truth analysis:

| | |
|---|---|
| **FCD** | GPS coordinates need to be sufficiently accurate to be mapmatched onto a digital representation of the road network (e.g. based on OSM) |

| | |
|---|---|
| | GPS coordinates need to be transmitted at a frequency of at least 0.1 Hz, ideally even 1 Hz (to reach 10m spatial accuracy) |
| | The size of the connected fleet should be sufficient to cover at least 5-10% of the total traffic on roads where RW or LC are to be expected. |
| | The dataset needs to have **unique** ID-attributes linking different GPS observations to the same vehicle, without gaps in the GPS trace ("FCD trip") |
| **RUF** | RUF messages need to be logged with corresponding coordinates, sufficiently accurate to be mapmatched onto a digital representation of the road network (e.g. based on OSM) |
| | RUF messages need to be logged with corresponding timestamps with at least second-level accuracy |
| | RUF messages need to be logged with a sufficiently distinctive and clear message text in order to ascertain the event type (in this case, RW or LC) |

*Table 13: FCD and RUF quality requirements*

When qualitative ground truth data is obtained, the related criteria can be calculated according to the TISA definitions:

| Criterion | Definition | Example | Measurement |
|---|---|---|---|
| Timeliness | Delay between event occurrence and availability in feed. | Unplanned closure reported within 1 min of occurrence. | Calculate time difference between occurrence and appearance in feed update. |
| Accuracy | Degree to which reported data matches reality (spatial). | Closure location within 10m of actual position; | Spatial: Compare GNSS coordinates/OpenLR length with ground truth. |
| Correctness | Degree to which all event attributes | Feed says, "Road closed due to road works," but | Compute % of correctly |

| | | | |
|---|---|---|---|
| | (type, timing, direction, impact) reflect reality. | road is open → incorrect. | reported attributes vs. ground truth. |
| Outdated messages deleted from feed | Expired events must be removed promptly. | Example: Closure ended at 2025-12-01T18:00; Message removed within 24 hours. | Track event across feed updates and compare end time with removal timestamp. |

*Table 14: Ground truth validation KPI's according to TISA*

How these calculations can be performed using FCD and RUF specifically is further discussed below.

### 14.5.1 Timeliness from FCD

As shown in the table above, the goal is to calculate the time difference between real-life occurrence and first appearance in the feed update. The real-life occurrence must thus be extracted from the (in this case) FCD ground truth dataset.

We distinguish two main impact types of a RW or LC:

(b) The road is completely closed, no traffic can pass
(b) The road is only partially blocked, i.e. capacity is reduced

The first case is readily detected by counting the FCD observations (assuming the data has sufficient coverage): when this drops to (near) zero, the road can be assumed to have been closed.

For the second case, the onset of both RW and LC, or the installment of a new speed limit (new road sign) will lead to reduced vehicle speeds on the road due to the reduction of capacity, following the fundamental relation

$$q = kv \tag{1}$$

with *q* the flow [veh/h], *k* the density [veh/km] and *v* the speed [km/h]. This speed reduction will show up as so called "trails" in the time-vs-distance TX-diagram which is a visual representation of the FCD derived speeds (the color scale). This is illustrated in the figure below.

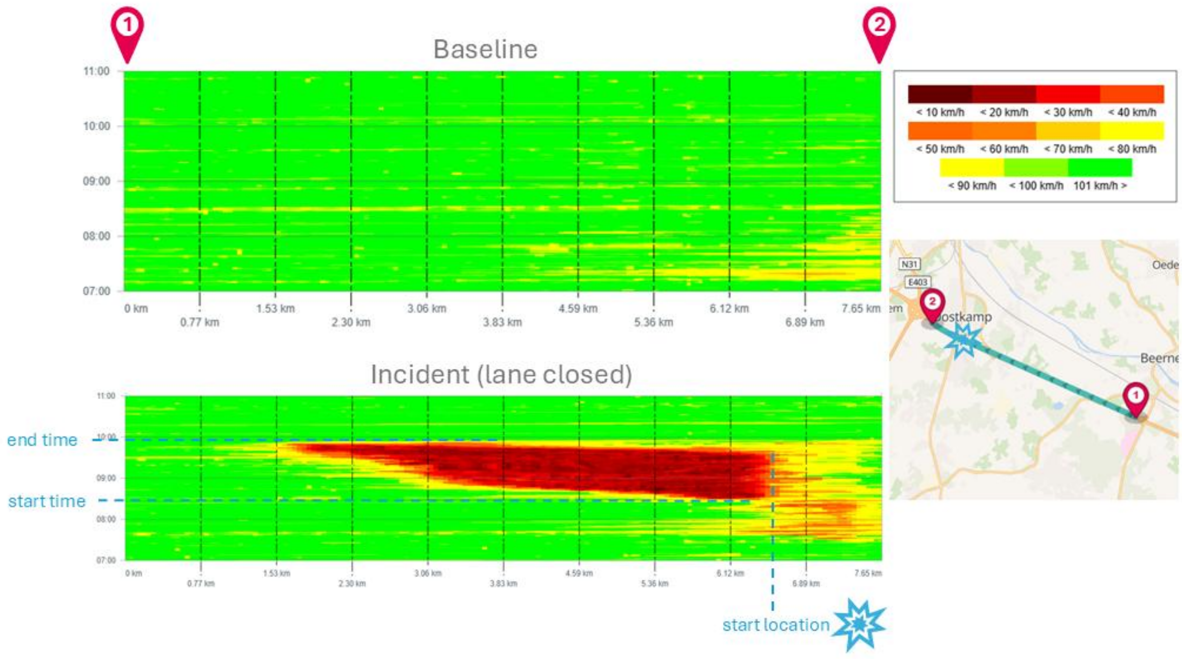



*Figure 24: The time-vs-distance TX-diagram*

This diagram depicts the speed along one given stretch of highway, as it develops through time. The baseline at the top shows that there is no structural congestion to be expected. In the bottom plot, at about 6.5 km along the stretch of road, at 8:30 am, we see that a sudden bottleneck appeared (in this case a collision), leading to the closure of a lane, with congestion spilling back along the highway for about 5 km. The jam finally ended a little before 10 am. From this kind of diagram, accurate start and end times of **the impact of a** RW or LC can be extracted. Note that, if the onset is e.g. at night, no impact may be created and the FCD-extracted times may be off. However, in this case we make the argument that we are extracting the **impact-relevant start and end times**, as the ultimate goal of this data is to improve end user services, which actually only require these impact-relevant start and end times to achieve real impact.

### 14.5.2 Accuracy from FCD

FCD is always defined on a given network definition of nodes and links. For example, this network can be that of OSM, or based on it. The spatial resolution of this network (i.e. the lengths of the links) together with the temporal resolution of the FCD collection (i.e. the collection frequency) determine the final spatial resolution with which the probe signals can be matched onto the network (in the TX-diagram example above, this is 50 m). For a full road closure, the start and end locations are simply the last and first network links where FCD observations are received. For a new speed limit sign, the positioning of the sign can be extracted from the TX-diagrams, as the location where the majority of drivers have changed their speed to the new limit. In the case where the new limit constitutes a speed increase, an additional "speeding-up" distance should be taken into account, which can be found from

$$s = (v^2 - u^2)/2a \tag{2}$$

where $s$ is the distance traveled [m], $v$ is the final speed (new speed limit) [m/s], $u$ is the initial speed (preceding speed limit) [m/s] and $a$ is the acceleration [m/s²]. A typical value for smooth, realistic acceleration with a modern person car is 2.5 m/s².

For partial road closures, the start location of the disruption can be read from the TX-diagrams. The end location of the closure is trickier, as we are only seeing the end of the *effect* of the closure (i.e. the congestion). However, once again, this gives us the **impact-relevant start and end locations**, as service providers are in fact mainly interested in where there is congestion (e.g. for routing) rather than where the actual closure is located.

### 14.5.3 Timeliness and accuracy from RUF

When RUF is available as ground truth data, the extracted start and end times/locations *can* be closer to the actual ones of the RW/LC themselves, compared to the impact-relevant ones extracted from FCD. Users usually have a separate option to report these, next to reporting congestion (regardless of the origin, structural or event-triggered).

However, RUF is more prone to statistical variance than FCD speeds. There is only a small coverage of FCD speeds from vehicles needed to have a very reliable interpretation of the actual speed driven at that time and place. At the same time, the coverage of a FCD data set is generally very consistent over time. RUF on the other hand, gains reliability through statistical representativeness as the amount of reports increase.

In other words, a single report of a lane closure can be accurate or inaccurate (where and when does the user press the button), and the more reports come in, the more sure one can be about the correct time and location through statistical analysis. A small number of FCD speed observations on the other hand, can be safely trusted to be accurate (assuming there is trust in a sufficient coverage).

These considerations mean we need to make the following distinction:

| Ground truth source | Timeliness | Accuracy | Statistical dependence on number of observations |
|---|---|---|---|
| **FCD** | Impact-relevant | Impact-relevant | low |

| | | | |
|---|---|---|---|
| **RUF** | Closer to situation on the road | Closer to situation on the road | high |

#### 14.5.4 Correctness

The relevant correctness attributes are

- Type: can be extracted directly from RUF (in this case: RW or LC). In case of a full road closure (which cannot be detected via RUF since users cannot use the road), this can be clearly seen from FCD speeds (cf. the IDEA principle already in use at NDW)
- Timing: see timeliness
- Direction: directly extractable from the consecutiveness of FCD observations
- Impact: directly extractable from the TX-diagrams. A full road closure is of course the most obvious one, but also a partial closure (i.e. a LC) can be derived by relating the reduction in speed to a reduction in capacity by using the fundamental relation (1).

### 14.5.5 Fusion of ground truth data sources: merge and decide

When there is both FCD and RUF ground truth data available for evaluation of the same data source, a process called data fusion is needed to calculate timeliness and accuracy. In practice, we suggest the following workflow for the evaluation of a specific event from the historical database:

1. Calculate the impact-relevant values using FCD, if the data is present. These values serve as a baseline estimate.
2. If RUF data is present:
    a. If the **trust level** of the RUF event crosses the threshold value T1, overwrite the FCD baseline values with the RUF values.
3. In the case only RUF data is present, the corresponding values should be accepted if the trust level is higher than T2.

The threshold levels T1 and T2 are part of the "**merge and decide"** process of the party executing the 5-Star Rating.

In an ideal world, trust levels are provided at event level in the data feed, and these trust levels are calculated according to a European standard in order to ensure comparability between different source providers.

# 15 Annex: PDV Plan Template

Is offered as separate document. Currently located on the TISGRADE Sharepoint: [PDV Plan in TISGRADE TEMPLATE.docx]

# 16 References

## 16.1 Tables



## 16.2 Figures